



2015 Minerals Yearbook

PLATINUM-GROUP METALS [ADVANCE RELEASE]

PLATINUM-GROUP METALS

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The platinum-group metals (PGMs) consist of iridium, osmium, palladium, platinum, rhodium, and ruthenium. The PGMs occur together in nature, but economic deposits are rare. PGMs are produced from deposits that are mined primarily for PGMs and are also produced as byproducts of nickel-copper mines.

In 2015, the United States was the world's fourth-leading producer of palladium and the fifth-leading producer of platinum. Stillwater Mining Co. (SMC, Billings, MT), the only domestic mine producer of PGMs, recovered PGMs from its Stillwater Mine southwest of Nye, MT, and its East Boulder Mine south of Big Timber, MT. Domestic production of palladium and platinum was 16,200 kilograms (kg), slightly more than that of 2014 (Stillwater Mining Co., 2016, p. 4).

Most of the world's supply of primary PGMs came from South Africa and Russia, which accounted for 58% and 24%, respectively, of global primary PGM production. World mine production of PGMs totaled 474,000 kg, a 21% increase from that of 2014, owing to increased production in South Africa following an unprecedented workers' strike in 2014. Recycling has become a significant source of PGMs as well, accounting for about 22% of the total global supply of palladium, platinum, and rhodium in 2015 (CPM Group, 2016, p. 31, 123, 177).

The prices of all PGMs decreased in 2015. The annual average palladium, platinum, rhodium, and ruthenium prices decreased by 14%, 24%, 19%, and 27% compared with those of 2014, and the iridium price decreased slightly (table 1).

In 2015, the automobile industry continued to be the major consumer of PGMs. Catalytic converters, also referred to as autocatalysts, accounted for approximately 84% of global rhodium consumption, 66% of palladium consumption, and 45% of platinum consumption (CPM Group, 2016, p. 35, 127, 197).

Legislation and Government Programs

The Defense Logistics Agency Strategic Materials, Department of Defense, reported no PGM sales from U.S. Government stockpiles in 2015; 15 kg of iridium and 261 kg of platinum remained in the stockpile. In addition, 0.12 kg of PGM alloys—palladium-cobalt wire—and 0.56 kg of PGM compounds were added to the stockpile in late 2014 and early 2015, respectively.

Production

Primary.—During 2015, U.S. palladium and platinum mine production was 12,500 kg and 3,670 kg, respectively, each slightly more than that of 2014 (table 1), and mine production of rhodium was 93 kg, 25% less than that in 2014. The Stillwater Mine produced 7,660 kg of palladium and 2,280 kg of platinum, decreases of 6% each compared with production in 2014. The East Boulder Mine produced 4,870 kg of palladium and

1,380 kg of platinum, increases of 14% each compared with 2014 production. SMC milled 1.33 million metric tons (Mt) of ore from the mines, 4% more than that of 2014. In 2015, the Stillwater Mine processed an average of 2,000 metric tons per day (t/d) of ore, having an average mill-head grade of 15.3 grams per metric ton (g/t) PGMs and a PGM mill recovery of 93%, about the same as that in 2014. In 2015, the East Boulder Mine processed an average of 1,590 t/d of ore, 11% more than in 2014, having an average mill-head grade of 12.5 g/t PGMs and a PGM mill recovery rate of about 91%, slightly more than that in 2014. The concentrates from the mines were smelted and then processed at the base-metals refinery at SMC's facilities in Columbus, MT, producing a PGM-rich filter cake. Final refining of PGMs was done by Johnson Matthey plc. Refined metal from SMC's mine production was sold to Tiffany & Co. and Johnson Matthey plc (Stillwater Mining Co., 2016, p. 8; 15–19; 49).

At yearend 2015, SMC reported proven and probable reserves at its Montana mines of 39.4 Mt of ore having an average grade of 15.7 g/t PGMs, a palladium-to-platinum ratio of about 3.4 to 1, and about 619,000 kg of contained palladium and platinum. These reserves are contained in the J-M Reef, an ore body within the layered mafic and ultramafic igneous rocks of the Stillwater Complex. SMC reported progress on its Blitz development project, a mine expansion project adjacent to the Stillwater Mine. The Blitz project would ultimately consist of two parallel underground drifts that would extend about 7,000 meters eastward from the Stillwater Mine. A new portal and decline from surface was permitted in 2015. The mine expansion infrastructure was expected to be completed in 2018. A second expansion project, the Graham Creek project, west of the East Boulder Mine, was completed and production began during the second quarter of 2014, ahead of schedule (Stillwater Mining Co., 2016, p. 11).

In 2015, PGM exploration continued in the Duluth Complex of Minnesota. Twin Metals Minnesota LLC (St. Paul, MN) continued to pursue the development of its Twin Metals Minnesota copper-nickel-PGM project. The Twin Metals project, planned as an underground mine, included three deposits in close proximity: the Birch Lake, Maturi, and Spruce Road deposits (Twin Metals Minnesota LLC, 2015).

In November, the final environmental impact statement (EIS) was completed for PolyMet Mining Corp.'s NorthMet project, and the U.S. Forest Service issued a draft record of decision on a land exchange for the project. In early 2016, the Minnesota Department of Natural Resources validated the EIS, and Polymet began the permitting process to construct and operate the NorthMet project. The NorthMet project was planned as an open pit mine, and ore was to be processed at the nearby Erie Plant facilities, originally used to process iron ore. Polymet expected construction and rampup to commercial production

to take about 24 months after receiving the permits (PolyMet Mining Corp., 2016, p. 14–15).

Secondary.—In 2015, PGMs were recycled from three main sources—catalytic converters, electronics, and jewelry. Globally, more than 124,000 kg of secondary PGMs was recovered, accounting for approximately 22% of the global supply of PGMs (CPM Group, 2016, p. 31, 123, 177).

Catalytic converters were the predominant source of secondary PGMs. An estimated 56,100 kg of PGMs was recovered from catalytic converters in the United States, which was about 54% of the world total; about 33,500 kg was recovered in Europe; about 11,900 kg in Japan; and 3,020 kg in China (CPM Group, 2016, p. 31, 122, 190).

Globally, about 76,900 kg of palladium was recovered from secondary sources. Of the total, 62,400 kg of palladium was recovered from catalytic converters (slightly more than that of 2014), 13,800 kg from electronics (slightly less than that of 2014), and 753 kg from jewelry (8% less than that of 2014) (CPM Group, 2016, p. 122).

Globally, about 39,800 kg of platinum was recovered from secondary sources including about 34,500 kg from recycled catalytic converters, which was slightly more than that of 2014. About 1,550 kg of platinum was recovered from electronics recycling in 2015, which was 5% more than the amount recovered in 2014. About 3,780 kg of platinum was recovered from the jewelry industry globally in 2015, 4% less than that of 2014. In 2015, recovery of rhodium from catalytic converters increased by 6% to 7,600 kg (CPM Group, 2016, p. 31, 190).

SMC reported that its recycling program recovered 17,100 kg of PGMs from spent catalytic converters in 2015, a 17% increase compared with that of 2014. Of the total recycled, SMC toll-refined 6,380 kg of PGMs, a 181% increase from that in 2014; the remainder was material purchased for its own accounts. In 2015, SMC sold 6,160 kg, 3,670 kg, and 746 kg, respectively, of recycled palladium, platinum, and rhodium, which were decreases of 10%, 12%, and 17%, respectively, compared with amounts sold in 2014 (Stillwater Mining Co., 2016, p. 8).

Consumption

Palladium.—Apparent domestic palladium consumption, defined as mine production plus imports minus exports, was 72,000 kg, a 13% decrease from 82,300 kg in 2014.

Global palladium consumption was about 287,000 kg in 2015, slightly more than that in 2014. About 66% of palladium was used by the catalytic converter industry, about 14% by the electronics industry, and about 8% and 5% by the dental and chemical industries, respectively. About 5% of palladium was used in the jewelry industry and the remainder was used in other industries and as investment (CPM Group, 2016, p. 126–127).

In 2015, global palladium use in catalytic converters reached an alltime high for the third consecutive year, increasing by 4% to 191,000 kg, owing to the greater number of vehicles sold in developed economies; tightening emission standards globally; higher demand for light trucks in the United States, which have higher loadings of PGMs; and an increase in the market share of gasoline engines in Europe. North America was the leading autocatalyst-consuming region, and accounted for 32% of global

consumption of palladium in catalytic converters (61,100 kg), 5% more than that of 2014. The United States accounted for about 85% of the North American consumption in this category (CPM Group, 2016, p. 124–125).

Palladium consumption in Europe for catalytic converters was 33,300 kg, an alltime high and 8% more than that of 2014, owing to an increase in auto sales, a decreased market share of diesel vehicles, and the introduction of more stringent emissions standards. Consumption by China's catalytic converter industry was 36,200 kg, 6% more than that of 2014 owing to tightening emissions standards and growing demand for gasoline-powered vehicles. Consumption by Japan was 22,900 kg, which was an 8% decrease compared with that of 2014. Palladium consumption for catalytic converters in the rest of the world increased by 5% to 37,200 kg (CPM Group, 2016, p. 130–133).

Global palladium consumption by the jewelry industry, which declined for the sixth straight year, was 13,900 kg, a slight decrease from that of 2014 and the lowest level since 2002. China remained the leading user of palladium for jewelry, accounting for 32% of world consumption in that industry. However, demand in China's jewelry industry decreased slightly relative to that of 2014 owing to a lack of marketing of palladium jewelry. Consumption in Europe was 1,990 kg of palladium, the same as that in 2014; consumption in North America and Japan was 2,120 kg and 3,240 kg, respectively, each slightly less than that in 2014. Consumption in the rest of the world was unchanged at about 2,050 kg (CPM Group, 2016, p. 134–135).

World palladium consumption in dental alloys was 22,600 kg in 2015, down slightly from consumption in 2014. Japan and North America accounted for about 35% and 31%, respectively, of the global palladium consumption in this industry. The chemical industry consumed 15,200 kg of palladium in 2015, slightly more than that in 2014. In the chemical industry, palladium was used as a catalyst in manufacturing bulk chemicals, including hydrogen peroxide, nitric acid, terephthalic acid, and vinyl acetate monomer, which in turn were used to produce many resins, plastics, and polyester and polyethylene terephthalate for use in textiles and packaging. Consumption of palladium by the electronics industry was 38,900 kg in 2015, slightly more than that of 2014 and the highest level since 2000. Most of the demand for palladium in the electronics industry was for multilayer ceramic capacitors, which have widespread use in electronic circuitry (CPM Group, 2016, p. 133–135).

The palladium investment sector was a net seller of palladium in 2015. Holdings in exchange-traded products (ETPs), decreased to about 70,900 kg at yearend 2015, a 23% decrease from holdings at yearend 2014 (CPM Group, 2016, p. 141).

Platinum.—In 2015, U.S. apparent consumption of refined platinum, defined as mine production plus imports minus exports, excluding waste and scrap, was 32,000 kg, 8% less than 34,700 kg in 2014.

In 2015, global platinum use, excluding investments, totaled 218,000 kg, unchanged from 2014. About 45% of the total was used to produce catalytic converters, about 34% by the jewelry industry, about 9% for chemical and petroleum refining, and about 3% in electronics. The remainder was used in other industries including glass manufacturing and the medical and biomedical industries. Worldwide use of platinum in the

catalytic converter industry was essentially unchanged from that of 2014 at 97,700 kg. In Europe, about 35,000 kg of platinum was consumed for catalytic converters, which was 5% more than that in 2014 owing to increased sales of commercial and passenger vehicles. Europe remained the leading consumer of platinum for catalytic converters and accounted for about 36% of total global consumption. Consumption of platinum for catalytic converters in the United States in 2015 was 23,100 kg, an 8% increase from 2014 owing to increased sales of large commercial vehicles that are typically powered by diesel engines that use platinum in their catalytic converters. The United States accounted for about 24% of global catalytic converter consumption. In Japan, platinum consumption for catalytic converters decreased by 5% in 2015 from that in 2014 to 18,300 kg, largely as a result of decreased demand for commercial vehicles. In China, consumption of platinum for catalytic converters decreased by 11% to 11,000 kg owing to a decline in sales of large commercial vehicles. Elsewhere, consumption of platinum for catalytic converters decreased by 9% in 2015 from that in 2014 to 10,300 kg (CPM Group, 2016, p. 32–42).

In 2015, global consumption of platinum in the jewelry industry decreased slightly to 74,000 kg compared with that in 2014. Consumption in the United States was 2,120 kg, 11% more than that in 2014. Consumption in China decreased by 4% to 56,800 kg and accounted for 77% of global consumption. Consumption in Europe was about 1,280 kg, the same as that in 2014; consumption in Japan was 8,680 kg, 4% more than that in 2014; and consumption in the rest of the world increased by 27% to 5,100 kg (CPM Group, 2016, p. 45).

Global use of platinum in chemicals and petroleum refining was 20,200 kg in 2015, slightly more than that of 2014. The leading use for platinum in chemical production was for catalysts used in the production of silicones and other chemicals, such as terephthalic acid used in the production of polyester fabric and plastic containers. Worldwide consumption of platinum in electrical applications was about 5,910 kg in 2015, slightly more than that of 2014 (CPM Group, 2016, p. 47–48).

Consumption of platinum for dental and medical applications was 1,150 kg, which was 3% less than that in 2014. Consumption in other end uses was essentially unchanged from that of 2014 at 16,700 kg. These other uses included platinum used in glassmaking equipment (CPM Group, 2016, p. 48).

Consumption of platinum for investment decreased in 2015 relative to that in 2014, but lack of transparency makes estimates difficult. Platinum holdings in ETPs globally totaled 78,000 kg at yearend 2015, 6% less than that at yearend 2014 (CPM Group, 2016, p. 58).

Other PGMs.—Global rhodium consumption in 2015 was 31,500 kg, 3% more than that of 2014, and the sixth consecutive year that global rhodium consumption increased. Most rhodium use, 84% in 2015, was in the production of catalytic converters. In 2015, rhodium use in catalytic converters was 26,500 kg, 4% more than that in 2014 owing to increased automobile production and tightening emissions standards. Use of rhodium in glass manufacturing increased slightly to 1,270 kg. Consumption of rhodium in chemical production increased by 5% to 1,620 kg in 2015 owing primarily to increased

consumption in China. Use in electronics was 1,370 kg, slightly more than that in 2014, and use in other applications was 686 kg, 3% more than that in 2014. (CPM Group, 2016, p. 191–194).

Global consumption of ruthenium increased by 9% to 29,400 kg in 2015 from that in 2014. Consumption of ruthenium in electrical applications was 14,200 kg, 27% more than that in 2014; electrochemical use was 4,910 kg, 3% more than that in 2014; use in chemical production was 6,690 kg, 13% less than that in 2014; and consumption in other applications increased by 8% to 3,640 kg (Johnson Matthey plc, 2016, p. 45).

Global consumption of iridium was 7,810 kg in 2015, 28% more than that of 2014. Use in electrical applications increased by 95% to 2,490 kg; use in the electrochemical applications was 1,770 kg, 14% more than that in 2014; use in chemical production was 622 kg, the same as that in 2014; and use in other applications was 2,920 kg, an 11% increase from that in 2014 (Johnson Matthey plc, 2016, p. 44).

Prices

According to Platts Metals Daily, in 2015, the Engelhard annual average prices for platinum, palladium, and rhodium decreased by 24%, 14%, and 19%, respectively, the price for ruthenium decreased by 27%, and that for iridium decreased slightly from those of 2014 (table 1).

Iridium.—The annual average iridium price in 2015 was \$544 per troy ounce, which was slightly less than that in 2014. The iridium price began the year at \$525 per troy ounce, increased to \$575 per troy ounce in late January, where it remained until late June, and then decreased to \$500 per troy ounce in late July. The price then increased to \$525 per troy ounce in early October, where it remained until yearend.

Palladium.—The annual average palladium price in 2015 was \$695 per troy ounce, which was 14% less than that in 2014. Palladium prices began 2015 at \$795 per troy ounce, fluctuated in a narrow range until late May, and then decreased to \$527 per troy ounce in late August, increased to \$726 per troy ounce in early October, and then decreased, ending the year at \$558 per troy ounce.

Platinum.—In 2015, the annual average platinum price was \$1,056 per troy ounce, which was 24% less than that of 2014, continuing a downward trend that began in 2012, following a record high of \$1,725 per troy ounce in 2011. Platinum began the year at \$1,198 per troy ounce, generally followed a downward trend to \$910 per troy ounce on October 1, rose to \$1,016 per troy ounce on October 19, and then decreased to \$888 per troy ounce at yearend. Platinum prices generally followed gold prices in response to global economic conditions.

Rhodium.—The annual average rhodium price in 2015 was \$955 per troy ounce, which was 19% less than that in 2014 and below \$1,000 per troy ounce for the first time since 2004. The rhodium price began the year at \$1,245 per troy ounce and generally trended downward throughout the year to \$670 per troy ounce at yearend. The rhodium annual average price in 2015 was below that for platinum, continuing the trend that began in 2012.

Ruthenium.—The annual average ruthenium price in 2015 was \$48 per troy ounce, which was 27% less than that of 2014, continuing a downward trend that began in 2010. The ruthenium

price began the year at \$58 per troy ounce, decreased to \$40 per troy ounce in late July, and then increased to \$42 per troy ounce in late August, where it remained until yearend.

Foreign Trade

In 2015, the U.S. net import reliance as a percentage of apparent consumption, calculated excluding trade data for waste and scrap, was estimated to be 83% for refined palladium and 89% for refined platinum. Imports for consumption of refined palladium in 2015 totaled 82,500 kg, an 11% decrease from that of 2014, with three countries accounting for about 76% of refined palladium imports in 2014—South Africa (34%), Russia (25%), and Italy (18%). Imports for consumption of platinum, excluding waste and scrap decreased by 7% in 2015 to 42,700 kg, from 141,000 kg in 2014. Excluding waste and scrap, the leading sources of platinum imports in 2015 were South Africa (43%), Germany (9%), and Italy and Russia (8% each). Imports for consumption of rhodium decreased by 4% compared with those in 2014 at 10,600 kg; imports of iridium and ruthenium decreased by 49% and 26%, respectively, and those of osmium decreased by 98% to 8 kg. Two countries accounted for 83% of the imports of iridium, osmium, rhodium, and ruthenium in 2015—South Africa (59%) and the United Kingdom (18%) (tables 2, 3).

Imports of waste and scrap totaled 196,000 kg in 2015, more than double the amount imported in 2014.

About 23,000 kg of palladium was exported in 2015, slightly more than that in 2014. Exports of platinum, excluding waste and scrap, decreased slightly, and exports of waste and scrap decreased by 3% compared with those in 2014. Exports of rhodium increased by 77% compared with exports in 2014, and combined exports of iridium, osmium, and ruthenium decreased by 13% during the same time period (table 4).

World Review

In 2015, world mine production of PGMs increased by 21% to 474,000 kg from 391,000 kg in 2014 (table 5). South Africa accounted for 58% of total PGM mine production in 2015; Russia, 24%; Canada, 6%; Zimbabwe, 5%; the United States, 3%; and other countries, 4%. In 2015, world platinum mine production increased by 29%. Platinum production in South Africa increased by 48% compared with that in 2014 owing to the rampup of production following a 5-month workers' strike in 2014, accounting for most of the increase in global production. South Africa produced 139,000 kg of platinum, which was 74% of world platinum production. Global mine production of palladium in 2015 increased by 12% to 215,000 kg, with Russia and South Africa each accounting for 38% of global production; Canada, 10%; Zimbabwe, 6%, and the United States, 5%. World mine production of other PGMs (iridium, osmium, rhodium, and ruthenium) increased by 34% in 2015 compared with that of 2014. South Africa, which accounted for 77% of global production of other PGMs, accounted for most of this increase.

Canada.—North American Palladium Ltd. produced 5,190 kg of palladium and 382 kg of platinum from its Lac des Isles Mine in Ontario, decreases of 4% and 6%, respectively, compared with production in 2014. The decreases were a result

of a 7-week mill shutdown to correct water-balance issues (North American Palladium Ltd., 2016, p. 3–4).

Vale S.A. (Brazil) produced 10,600 kg of palladium and 4,790 kg of platinum as byproducts of its nickel operations at Sudbury, Ontario, decreases of 17% and 18%, respectively, from production in 2014. Glencore plc (formerly Glenore Xstrata plc) (Switzerland) produced PGMs as byproducts from nickel mining operations at Sudbury and the Raglan Mine in Quebec. In 2015, Glencore produced 4,880 kg of palladium and 2,360 kg of platinum, 7% less palladium and 5% more platinum relative to 2014 (Glencore plc, 2016, p. 53; Vale S.A., 2016, p. 48).

Russia.—PJCS MMC Norilsk Nickel produced 81,100 kg of palladium and 19,300 kg of platinum in 2015, slightly less for both metals, compared with 2014 production (PJCS MMC Norilsk Nickel, 2016, p. 65).

South Africa.—Platinum production in South Africa returned to a normal level in 2015 after the 5-month-long workers' strike in South Africa ended in 2014. The strike was the longest in South Africa's mining history. Production of palladium and platinum increased by 42% and 48%, respectively, in 2015 compared with 2014.

The world's leading PGM producer, Anglo American Platinum Ltd. (Amplats), reported primary equivalent refined platinum production of 57,100 kg in 2015, a 38% increase compared with that in 2014. Production of palladium in 2015 was 42,700 kg, a 29% increase compared with 2014. Amplats agreed to sell its Rustenburg mining and concentrating operations to Sibanye Gold Ltd. for no less than 4.5 billion rand (\$325 million). The sale included the Bathopele, Siphumelele, and Thembelani mining operations (which comprise the integrated Khuseleka and Khomanani mining operations), two concentrating plants, a chromium-recovery plant, and the Western Limb Tailings Retreatment plant. As part of the deal, Sibanye was to sell all concentrates back to Amplats through the end of 2018. Starting January 1, 2019, Sibanye and Amplats would enter a toll treatment arrangement whereby Amplats would smelt and refine concentrate produced from the Rustenburg mines for a period of 2 to 8 years. The sales agreement was subject to various approvals and was expected to become unconditional during 2016 with a backstop date of June 30, 2017. Going forward, Amplats planned to focus on lower cost mechanized mining operations. Sibanye also entered into an agreement to purchase the platinum mining operations of Aquarius Platinum Ltd. (Bermuda) (Anglo American Platinum Ltd., 2015; CPM Group, 2016, p. 14).

Production at Impala Platinum Holdings Ltd.'s South African mining operations during its reporting year of July 1, 2014, through June 30, 2015, was 13,800 kg of palladium and 25,400 kg of platinum, which were increases of 74% and 88%, respectively, compared with 2014 production. Lonmin plc (United Kingdom) produced 11,300 kg of palladium and 24,700 kg of platinum in 2014, more than double the amounts produced in 2014 (CPM Group, 2016, p. 13, 112).

Zimbabwe.—In 2015, palladium production decreased slightly and platinum production increased slightly compared with 2014 (table 5). Zimplats Holdings Ltd. continued to redevelop the Bimha Mine following its collapse in 2014. Return to full production was expected to occur in 2018. In January, the Government of Zimbabwe imposed a 15%

export tax on unrefined platinum in order to encourage mining companies to establish local PGM refining capability. The tax was suspended in August so that mining companies would have 2 years to build refining capability (CPM Group, 2016, p. 18).

Outlook

Palladium, platinum, and rhodium are used primarily in catalytic converters in automobiles to decrease harmful emissions; therefore, the performance of the automobile industry will have the greatest impact on future consumption of these PGMs. Global automobile production is expected to increase, particularly in emerging markets, such as China and India, as well as in developed markets in the United States and Europe; therefore, an overall increase in demand for PGMs in catalytic converters is expected. The automobile markets in China and the United States are predominantly gasoline-powered vehicles; therefore, the increase in automobile demand in those markets will likely affect palladium demand in particular. Platinum demand will likely increase in European diesel vehicles owing to the implementation of Euro 6 emission standards. Platinum demand in the jewelry industry is expected to decrease slightly. In the electronics industry, palladium demand is expected to increase slightly. Rhodium consumption is expected to increase as a result of higher vehicle production in many areas of the world as well as tightening emission standards. Ruthenium demand in the electronics industry is expected to be unchanged, because decreased production of personal computers is expected to be offset by increased applications in data centers. Ruthenium is used largely in computer hard drives. Iridium demand is likely to increase in the electronics industry, in which iridium crucibles are used in the manufacture of light-emitting diode lights.

Platinum production levels from South Africa are expected to decrease. Production levels will remain vulnerable to problems in the South African mining industry, including work stoppages caused by labor disputes and safety issues, and to ongoing restructuring of the platinum mining industry, including closure of unprofitable mines. Supply from Zimbabwe is expected to increase owing to ongoing mine expansions but is subject to political stability. Palladium supply is expected to decrease slightly owing to lower production in South Africa and Russia. Recycling of platinum and palladium is expected to increase, particularly from automotive catalysts, although the quantity of material available for recycling is very price sensitive, with higher metal prices leading to a greater amount of recycling, and lower metals prices leading to reduced recycling.

References Cited

- Anglo American Platinum Ltd., 2015, Anglo American Platinum Limited announces the sale of its Rustenburg operations for at least R4.5 billion (nominal terms) to Sibanye Gold Limited and withdrawal of cautionary announcement: Johannesburg, South Africa, Anglo American Platinum Ltd. news release, September 9. (Accessed September 16, 2015, at <http://www.angloplatinum.com/media/press-releases/2015/09-09-2015.aspx>.)
- CPM Group, 2016, The CPM platinum group metals yearbook 2016: New York, NY, CPM Group, 209 p.
- Glencore plc, 2016, Annual report 2015: Baar, Switzerland, Glencore plc, 202 p. (Accessed June 21, 2016, at http://www.glencore.com/assets/investors/doc/reports_and_results/2015/GLEN-2015-Annual-Report.pdf.)
- Johnson Matthey plc, 2016, PGM market report May 2016: London, United Kingdom, Johnson Matthey plc, 50 p. (Accessed January 15, 2017, at <http://www.platinum.matthey.com/documents/new-item/pgm%20market%20reports/pgm-market-report-may-2016.pdf>.)
- North American Palladium Ltd., 2016, 2015 annual report: Toronto, Ontario, Canada, North American Palladium Ltd., 62 p. (Accessed December 15, 2016, at http://s21.q4cdn.com/326998455/files/doc_financials/2015/Annual-Report-FINAL.pdf.)
- PJCS MMC Norilsk Nickel, 2016, Annual report 2015: Moscow, Russia, PJSC MMC Norilsk Nickel, 240 p. (Accessed September 25, 2016, at http://www.nornik.ru/assets/files/2016/ANUAL-REPORT-2015_NN_En_Web.pdf.)
- PolyMet Mining Corp., 2016, Form 20-F for the fiscal year ended January 31, 2016: U.S. Securities and Exchange Commission, 62 p. (Accessed June 27, 2017, at <http://polymetmining.com/wp-content/uploads/2013/02/SEDAR-Jan-31-2015-PolyMet-Annual-Report-on-20F.pdf>.)
- Stillwater Mining Co., 2016, 2015 annual report: Billings, MT, Stillwater Mining Co., 112 p. (Accessed August 25, 2016, at http://www.annualreports.com/HostedData/AnnualReports/PDF/NYSE_SWC_2015.pdf.)
- Twin Metals Minnesota LLC, 2015, Developing Minnesota's first underground mine in 50 years: St. Paul, MN, Twin Metals Minnesota LLC, December 5. (Accessed June 27, 2017, at <http://www.twin-metals.com/developing-minnesotas-first-underground-mine-in-50-years/>.)
- Vale S.A., 2016, Form 20-F for the fiscal year ended December 31, 2015: U.S. Securities and Exchange Commission, 174 p. (Accessed April 28, 2017, at http://www.vale.com/EN/investors/information-market/annual-reports/20f/20FDocs/Vale%2020-F%202015_i.PDF.)

GENERAL SOURCES OF INFORMATION

U.S. Geological Survey Publications

- Flow Studies for Recycling Metal Commodities in the United States. Circular 1196, 2011.
- Global Exploration and Production Capacity for Platinum-Group Metals from 1995 Through 2015. Scientific Investigations Report 2012–5164, 2012.
- Historical Statistics for Mineral and Material Commodities in the United States. Data Series 140.
- Platinum-Group Metals. Ch. in Mineral Commodity Summaries, annual.
- Platinum-Group Metals. Ch. in United States Mineral Resources, Professional Paper 820, 1973.
- Platinum-Group Metals. International Strategic Minerals Inventory Summary Report, Circular 930–E, 1986.
- Platinum-Group Metals. Mineral Industry Surveys, monthly, since January 2004.
- Precious Metals. Mineral Industry Surveys, monthly, through December 2003.
- Platinum-Group Metals [Ir, Os, Pd, Pt, Rh, Ru] Ch. in Metal Prices in the United States Through 2010, Scientific Investigations Report 2012–5188, 2013.
- Platinum-Group Metals—World Supply and Demand. Open File Report 2004–1224, 2005.
- Review of Selected Global Mineral Industries in 2011 and an Outlook to 2017. Open-File Report 2013–1091.

Other

- CPM Group.
- Defense Logistics Agency Strategic Materials.
- International Platinum Association.
- Platinum-Group Metals. Ch. in Mineral Facts and Problems, U.S. Bureau of Mines Bulletin 675, 1985.
- Platinum Guild International.
- Roskill Information Services Ltd.
- Thomson Reuters GFMS Surveys.

TABLE 1
SALIENT PLATINUM-GROUP METALS STATISTICS¹

		2011	2012	2013	2014	2015
United States:						
Mine production: ²						
Palladium, Pd content:						
Quantity	kilograms	12,400	12,300	12,600	12,400	12,500
Value	thousands	\$295,000	\$257,000	\$295,000	\$324,000	\$280,000
Platinum, Pt content:						
Quantity	kilograms	3,700	3,670	3,720	3,660	3,670
Value	thousands	\$205,000	\$184,000	\$178,000	\$163,000	\$125,000
Refinery production:						
Palladium, Pd content:						
Quantity	kilograms	17,500	21,000	23,900	23,700	19,800
Value	thousands	\$414,000	\$438,000	\$499,000	\$495,000	\$413,000
Platinum, Pt content:						
Quantity	kilograms	15,500	16,600	19,100	18,900	19,200
Value	thousands	\$859,000	\$831,000	\$956,000	\$946,000	\$959,000
Imports for consumption, refined:						
Iridium, Ir content	kilograms	2,790	1,230	1,720	1,990	1,010
Osmium, Os content	do.	48	130	77	322	8
Palladium, Pd content	do.	98,900	80,100	83,100	92,400	82,500
Platinum, includes waste, scrap, and coins, Pt content	do.	129,000	172,000	116,000	141,000	239,000
Rhodium, Rh content	do.	13,100	12,800	11,100	11,100	10,600
Ruthenium, Ru content	do.	13,300	10,200	15,300	11,100	8,230
Exports, refined:						
Iridium, osmium, and ruthenium, gross weight	do.	1,150	1,640	1,320	901	781
Palladium, Pd content	do.	32,000	32,200	25,900	22,500	23,000
Platinum, Pt content	do.	11,300	8,630	11,200	14,800	14,400
Rhodium, Rh content	do.	1,370	1,040	1,220	428	758
Stocks, National Defense Stockpile, December 31:						
Iridium, Ir content	do.	18	18	18	15 ^r	15
Platinum, Pt content	do.	261	261	261	261	261
Price, average: ³						
Iridium	dollars per troy ounce	1,035.87	1,066.23	826.45	556.19	544.19
Palladium	do.	738.51	649.27	729.58	809.89	694.99
Platinum	do.	1,724.51	1,555.39	1,489.57	1,387.89	1,056.09
Rhodium	do.	2,024.35	1,274.98	1,069.10	1,174.23	954.90
Ruthenium	do.	165.85	112.26	75.63	65.13	47.63
Employment		1,570	1,660	1,770	1,620	1,440
World, mine production, PGM content	kilograms	491,000	453,000 ^r	461,000 ^r	391,000 ^r	474,000

^rRevised. do. Ditto.

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

²Source: Stillwater Mining Co., 2016, 2015 annual report: Littleton, CO, Stillwater Mining Co., p. 49.

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

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)	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)
2014	685	\$31,100	34,400	\$1,500,000	6,230	\$282,000	4,290	\$166,000	95,600	\$1,090,000	208	\$8,990
2015:												
Argentina	--	--	--	--	2	61	--	--	319	11,200	--	--
Australia	--	--	--	--	--	--	--	--	842	18,800	361	12,700
Belgium	--	--	327	10,700	--	--	--	--	221	2,840	--	--
Bolivia	--	--	--	--	--	--	--	--	84	1,860	--	--
Brazil	--	--	--	--	--	--	13	342	929	25,000	--	--
Canada	27	922	--	--	(2)	22	169	6,060	17,300	52,700	413	15,300
Chile	--	--	--	--	--	--	--	--	225	7,050	--	--
China	--	--	--	--	570	22,800	17	415	3,600	38,500	--	--
Colombia	--	--	--	--	939	28,000	--	--	91	2,080	--	--
Czech Republic	--	--	--	--	--	--	160	5,510	8	130	--	--
France	--	--	379	13,900	48	1,670	219	7,630	1,760	36,600	--	--
Germany	14	430	1,680	54,200	238	8,970	2,010	61,300	13,000	164,000	86	5,750
Hungary	--	--	--	--	--	--	--	--	198	7,350	--	--
Indonesia	--	--	--	--	--	--	--	--	202	4,000	--	--
Israel	--	--	--	--	--	--	(2)	6	121	1,820	--	--
Italy	--	--	3,300	114,000	9	332	4	52	32,400	61,200	--	--
Japan	--	--	85	3,110	13	469	37	1,340	2,200	63,300	--	--
Korea, Republic of	186	5,820	2,140	76,700	118	4,640	1	19	17,600	17,300	--	--
Malaysia	--	--	--	--	--	--	--	--	263	3,880	--	--
Mexico	--	--	--	--	38	1,320	(2)	5	1,400	28,100	--	--
Netherlands	--	--	--	--	--	--	--	--	72	1,350	--	--
New Zealand	--	--	--	--	--	--	--	--	26	851	(2)	3
Norway	--	--	1,340	46,500	--	--	--	--	13	335	--	--
Poland	--	--	--	--	--	--	--	--	12,600	13,700	--	--
Qatar	--	--	--	--	--	--	--	--	64	2,440	--	--
Russia	37	1,430	1,490	41,800	356	13,900	1,640	58,900	--	--	(2)	5
Saudi Arabia	--	--	36	1,480	17	855	--	--	1,360	43,700	--	--
Singapore	51	2,020	223	9,630	522	20,900	63	3,130	5,110	161,000	(2)	6
South Africa	409	10,300	16,200	571,000	1,020	37,500	852	26,100	--	--	64	2,510
Switzerland	94	3,120	141	5,510	802	24,100	597	21,100	8	228	78	3,480
Taiwan	--	--	--	--	--	--	22	530	7,360	49,000	--	--
Thailand	--	--	--	--	--	--	--	--	245	4,570	--	--
Trinidad and Tobago	--	--	--	--	--	--	--	--	174	6,160	--	--
United Kingdom	--	--	2,620	90,700	48	1,440	145	4,260	75,200	63,000	210	3,880
Venezuela	--	--	--	--	--	--	1	33	115	3,890	--	--
Other	2	39	--	--	5	170	12	285	1,010	5,840	(2)	126
Total	820	24,100	30,000	1,040,000	4,750	167,000	5,960	197,000	196,000	903,000	1,210	43,700

-- 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.

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)
2014	79,300	\$2,020,000	13,100	\$350,000	1,990	\$33,900	322	\$1,670	11,100	\$24,600	11,100	\$408,000
2015:												
Austria	--	--	179	4,830	--	--	--	--	--	--	--	--
Belgium	1,170	14,200	--	--	2	38	--	--	487	824	315	8,810
Brazil	83	1,620	--	--	--	--	--	--	--	--	--	--
Canada	1,240	9,990	3,820	93,300	--	--	--	--	--	--	(3)	14
China	--	--	--	--	--	--	8	59	--	--	140	5,660
France	1	20	8	275	--	--	--	--	--	--	157	4,170
Germany	892	18,300	47	932	143	2,570	--	--	296	714	661	23,400
Italy	13,500	338,000	1,020	25,600	5	40	--	--	1	3	332	10,700
Japan	708	7,250	13	338	152	2,640	--	--	--	--	78	2,910
Korea, Republic of	5,010	119,000	615	11,800	--	--	--	--	--	--	699	21,900
Mexico	--	--	21	223	--	--	--	--	--	--	1	30
Norway	2,510	55,600	--	--	--	--	--	--	--	--	50	1,510
Russia	16,600	366,000	3,670	84,500	13	295	--	--	8	14	1,040	32,100
South Africa	27,600	635,000	67	2,560	453	7,500	--	--	5,560	10,000	5,640	179,000
Switzerland	1,260	31,500	46	1,320	--	--	--	--	1	3	--	--
United Kingdom	2,300	55,500	98	2,270	243	4,280	--	--	1,880	3,020	1,480	45,800
Other	--	--	1	13	2	11	--	--	--	--	(3)	11
Total	72,900	1,650,000	9,600	228,000	1,010	17,400	8	59	8,230	14,600	10,600	336,000

-- 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 (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)
2014	22,500	\$460,000	14,800	\$596,000	254,000	\$1,060,000	901	\$13,200	428	\$17,000
2015:										
Argentina	--	--	151	5,580	--	--	--	--	--	--
Australia	71	1,550	171	5,670	--	--	28	786	--	--
Austria	2	15	1	40	--	--	1	4	--	--
Belgium	2	30	794	25,400	28,600	12,500	6	69	62	1,630
Brazil	206	4,990	65	1,650	--	--	--	--	5	186
Canada	2,550	51,800	194	7,330	51	910	5	46	1	91
Chile	1	20	(2)	12	--	--	--	--	--	--
China	1,420	36,400	96	2,130	9	385	10	233	378	10,700
Colombia	42	830	(2)	8	--	--	--	--	--	--
Costa Rica	34	496	23	453	--	--	--	--	--	--
Czech Republic	20	196	18	409	--	--	--	--	2	366
Denmark	34	581	(2)	17	--	--	--	--	--	--
Dominican Republic	--	--	13	312	--	--	--	--	--	--
Finland	19	100	(2)	5	--	--	--	--	--	--
France	422	4,320	40	1,290	--	--	13	206	20	707
Germany	3,570	69,500	4,040	136,000	4,690	52,200	197	3,960	154	7,330
Hong Kong	685	14,200	90	3,100	1	37	238	4,600	25	807
India	558	12,600	362	13,100	473	16,400	127	1,480	53	1,720
Ireland	237	2,020	391	11,700	--	--	--	--	--	--
Israel	1,260	6,740	7	251	--	--	--	--	--	--
Italy	197	3,850	198	7,490	12	272	--	--	--	--
Japan	301	2,790	1,310	41,100	185,000	137,000	44	887	(2)	18
Korea, Republic of	1,640	36,200	1,330	44,300	--	--	51	461	--	--
Laos	4	105	50	1,890	--	--	--	--	--	--
Luxembourg	1,370	30,600	811	25,800	37	1,180	--	--	--	--
Malaysia	11	92	5	78	--	--	1	31	--	--
Mexico	303	3,240	475	11,500	14	408	5	81	1	66
Netherlands	14	74	77	2,350	117	1,680	14	336	10	347
New Zealand	20	565	1	92	--	--	3	13	--	--
Norway	28	637	(2)	7	--	--	--	--	--	--
Peru	2	97	2	55	--	--	--	--	--	--
Philippines	3	40	3	105	--	--	--	--	--	--
Poland	4	60	1	21	--	--	--	--	--	--
Russia	18	598	--	--	--	--	--	--	--	--
Saudi Arabia	52	482	(2)	4	--	--	--	--	--	--
Singapore	17	486	2,070	69,500	291	65	1	7	41	1,580
Slovakia	--	--	36	825	--	--	--	--	--	--
Spain	12	233	--	--	--	--	--	--	--	--
Sweden	35	77	(2)	47	--	--	(2)	4	--	--
Switzerland	1,980	47,700	315	10,700	7,850	171,000	1	4	--	--
Taiwan	1,230	21,500	18	722	(2)	3	7	126	(2)	24
Thailand	112	3,160	131	4,210	--	--	--	--	(2)	23
Turkey	--	--	2	107	--	--	--	--	6	142
United Arab Emirates	12	79	--	--	--	--	1	3	(2)	6
United Kingdom	4,510	99,200	1,100	33,200	19,400	492,000	24	402	(2)	3
Uruguay	8	21	4	205	--	--	4	18	--	--
Vietnam	1	13	23	825	--	--	--	--	--	--
Other	13	93	1	91	--	--	1	22	(2)	26
Total	23,000	458,000	14,400	470,000	246,000	886,000	782	13,800	759	25,800

-- 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.

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

(Kilograms)

Country ³	2011	2012	2013	2014	2015
Palladium:					
Australia ^{e,4}	350	300	320	320	310
Botswana	2,115	2,613	1,337	560 ^e	200
Canada ^c	17,400	17,300	16,500	20,000	21,000
Finland	1,058	1,100 ^e	1,100 ^e	902	2,400
Japan ⁵	7,534	8,052	6,239	6,969	5,300
Poland ^{e,6}	10 ^r	20 ^r	30 ^r	20 ^r	20
Russia ^c	84,000 ⁷	82,000	80,000	83,000	81,000
Serbia ^c	4 ⁷	22 ⁷	20	20	20
South Africa	82,731	74,738	76,008 ^r	58,410	82,691
United States ⁸	12,400	12,300	12,600	12,400	12,500
Zimbabwe ^c	8,241 ⁷	7,800	9,600	10,100	10,000
Total	216,000	206,000	204,000^r	193,000	215,000
Platinum:					
Australia ^{e,4}	95	90	90	90	90
Botswana	373	435	218	93	90
Canada ^c	8,000	7,500	7,000	8,500	7,600
Colombia	1,231	1,460	1,836	1,600 ^r	1,300
Finland	836 ^r	429	946	1,060	1,030
Japan ⁵	1,765	1,735	1,963	1,724	1,700 ^c
Poland ^{e,6}	20 ^r	40 ^r	50 ^r	40 ^r	40
Russia ^c	27,300	26,500	25,500	23,000	22,000
Serbia	6	3	3	3	3
South Africa	148,008	128,590	137,024 ^r	93,991	139,125
United States ⁸	3,700	3,670	3,720	3,660	3,670
Zimbabwe ^c	10,826 ⁷	10,500	12,400	12,500 ^r	12,600
Total	202,000	181,000	191,000^r	146,000	189,000
Other platinum-group metals:^c					
Canada	800	750	1,000	900	900
Russia	12,000	12,000	12,000	12,000	12,000
South Africa ⁷	58,111 ⁵	51,010 ^r	51,156 ^r	36,043 ^r	53,699
Zimbabwe	1,820	2,200	2,700	2,700	2,700
Total	72,700	66,000^r	66,900^r	51,600^r	69,300
Grand total	491,000	453,000^r	461,000^r	391,000^r	474,000

^eEstimated. ^rRevised.

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

²Includes data available through October 13, 2017. Platinum-group metal (PGM) production by Germany, Norway, Switzerland, and the United Kingdom was not included, because the production was 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 were thought to produce PGMs, and several other countries may also have done so, but output was not reported quantitatively, and there was no reliable basis for the formulation of estimates of output levels. A part of this output not specifically reported by country was, however, presumably included in this table and credited to Japan.

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

⁵Production derived entirely from imported ores.

⁶Poland's official estimates were based on reported platinum- and palladium-bearing final (residual) slimes and then average platinum and palladium content from electrolytic copper refining.

⁷Reported figure.

⁸Byproduct platinum and palladium produced from gold-copper ores were excluded.