



# 2018 Minerals Yearbook

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## PLATINUM-GROUP METALS [ADVANCE RELEASE]

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# PLATINUM-GROUP METALS

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In 2018, the United States was the world's fourth-leading producer of palladium and the fifth-leading producer of platinum (table 5). Sibanye Gold Ltd. (Sibanye-Stillwater, South Africa), the only domestic mine producer of non-byproduct platinum-group metals (PGMs), recovered PGMs from its Stillwater and Boulder Mines in Montana. Domestic production of palladium and platinum was 14,300 kilograms (kg) and 4,160 kg, a slight increase and a 4% increase, respectively, from that estimated for 2017 (Sibanye Gold Ltd., 2019b, p. 35). Recycling was a significant source of PGMs as well, accounting for about 29% of the total global supply of palladium, platinum, and rhodium in 2018 (Cowley, 2019, p. 35, 39, 43).

In 2018, the automobile industry continued to be the major consumer of PGMs. Catalytic converters accounted for approximately 85% of global rhodium consumption, 85% of palladium consumption, and 39% of platinum consumption (CPM Group, 2019, p. 7, 107, 173). The annual average prices for iridium, palladium, rhodium, and ruthenium increased by 42%, 19%, 100%, and 218%, respectively, compared with those of 2017, whereas the platinum price decreased by 7% (fig. 1, table 1). In 2018, excluding waste and scrap, imports of PGMs increased by 10%, and exports increased by 9%. Note that exports of iridium, osmium, and ruthenium are reported in gross weight because they are not reported separately when exported (table 1). World mine production of PGMs totaled 471,000 kg, a 3% increase from the revised total in 2017. Most of the world's mine supply of PGMs was produced in South Africa and Russia, which accounted for 58% and 25%, respectively, of global PGM mine production (table 5).

The PGMs are 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 chromite or nickel-copper mines.

## Legislation and Government Programs

The Defense Logistics Agency Strategic Materials, U.S. Department of Defense, reported no PGM sales in 2018. At yearend, the National Defense Stockpile contained 15 kg of iridium, 261 kg of platinum, and less than 1 kg each of palladium and palladium-cobalt wire. In addition, 10 kg of PGM compounds was added to the stockpile in 2018.

In May, the U.S. Department of the Interior, in coordination with other executive branch agencies, published a list of 35 critical mineral commodities, including PGMs (U.S. Department of the Interior, Office of the Secretary, 2018). The list was developed to serve as an initial focus pursuant to Executive Order 13817, "A Federal Strategy to Ensure Secure and Reliable Supplies of Critical Minerals" (Trump, 2017).

In April 2018, under section 301(b) of the Trade Act of 1974, as amended, the Office of the U.S. Trade Representative

(USTR) determined that acts, policies, and practices of China related to technology transfer, intellectual property, and innovation were discriminatory or unreasonable and those actions burdened or restricted United States commerce (Office of the U.S. Trade Representative, 2018b, p. 47974–48192). As a result, the USTR imposed an additional import duty of 25% on an initial list of products from China in June 2018, including PGMs (Office of the U.S. Trade Representative, 2018a, p. 28710–28756). An additional 10% ad valorem duty was imposed in September 2018, which also included PGMs, and would increase to 25% in January 2019 (Office of the U.S. Trade Representative, 2018c, p. 47974–48192). PGM-containing materials subject to the section 301 actions included the following Harmonized Tariff Schedule of the United States codes: 7110.11.00 (platinum, unwrought or in powder form), 7110.19.00 (platinum, in semimanufactured forms), 7110.21.00 (palladium, unwrought or in powder form), 7110.29.00 (palladium, in semimanufactured forms), 7110.31.00 (rhodium, unwrought or in powder form), 7110.39.00 (rhodium, in semimanufactured forms), 7110.41.00 (iridium, osmium and ruthenium, unwrought or in powder form), 7110.49.00 (iridium, osmium and ruthenium, in semimanufactured forms), 7112.92.00 (platinum waste and scrap), and 7115.10.00 (platinum catalysts in the form of wire cloth or grill) (Office of the U.S. Trade Representative, 2018d).

## Production

**Mine.**—During 2018, U.S. palladium and platinum mine production was 14,300 kg and 4,160 kg, respectively. Compared with 2017, this represented a slight increase in palladium and an increase of 4% for platinum (table 1) (Sibanye Gold Ltd., 2019b, p. 35).

Sibanye-Stillwater produced PGMs from two mines in the United States, the Stillwater Mine and the East Boulder Mine, both located in Montana. In 2018, the Stillwater Mine produced 11,300 kg of PGMs, and the East Boulder Mine produced 7,110 kg of PGMs. Sibanye-Stillwater processed 1.34 million metric tons (Mt) of ore from the mines with a combined mill-head grade of 15 grams per metric ton PGMs and a PGM mill recovery rate of 91%. The concentrates from the mines were smelted and then processed at the base-metals refinery at Sibanye-Stillwater's metallurgical complex in Columbus, MT, producing a PGM-rich filter cake. Final refining of PGMs to commercial grade was done by Johnson Matthey Plc (United Kingdom). Refined metal from Sibanye-Stillwater's mine production was sold to Tiffany & Co. and Johnson Matthey Plc (Sibanye Gold Ltd., 2019a, p. 13, 50, 52).

At yearend 2018, Sibanye-Stillwater reported proven and probable reserves at its Montana mines of 46.4 Mt of ore with a palladium-to-platinum ratio ranging from 3.4:1 to 3.6:1 and about 797,000 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 (Sibanye Gold Ltd., 2019a, p. 328–329). Production from the Blitz development project, a mine expansion project adjacent to the Stillwater Mine, continued and contributed to the increase in production for 2018. Full production from the Blitz project was expected by late 2022 (Sibanye Gold Ltd., 2019b, p. 3). Effective July 1, 2018, Wheaton Precious Metals Corp. would acquire 100% of the gold and a percentage of the palladium (4.5% decreasing to 2.25% and then to 1% over time after set delivery amounts) produced at East Boulder and Stillwater over the life of the mines (Wheaton Precious Metals Corp., 2018).

In 2018, two PGM exploration projects in the Duluth Complex of Minnesota continued to progress towards development. On November 1, PolyMet Mining, Inc. (PolyMet) (Canada) announced that it had received a mining permit from the State of Minnesota for its NorthMet copper-nickel-PGM project in the Duluth Complex. The permit would allow PolyMet to construct and run open pit mines with an expected 20-year mine production of nearly 50,000 kg of precious metals. The ore would be processed at the company's nearby Erie Plant facilities, originally used to process iron ore (PolyMet Mining, Inc., 2018). Twin Metals Minnesota LLC (St. Paul, MN), a wholly owned subsidiary of Antofagasta plc, 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. In May, Twin Metals was notified that the Bureau of Land Management, U.S. Department of the Interior, was reinstating two mineral leases in northeastern Minnesota held by the company (Twin Metals Minnesota LLC, 2018).

**Refinery.**—The U.S. Geological Survey surveyed domestic precious-metals refinery producers on an annual basis. Of the 21 companies that were surveyed for commercial-grade PGM refinery production in 2018, 6 companies responded. Refinery production for the non-respondents was estimated based on prior reports or on information from other sources; however, it was still likely underestimated.

During 2018, U.S. palladium and platinum refinery production was 26,600 kg and 24,800 kg, respectively. Compared with the revised data for 2017, production decreased by 30% for palladium and by 11% for platinum (table 1).

**Recycling.**—In 2018, PGMs were recycled from three main sources—catalytic converters, electronics, and jewelry. Globally, more than 173,000 kg of secondary PGMs was recovered, accounting for approximately 29% of the global supply of PGMs. Catalytic converters were the predominant source of secondary PGMs. An estimated 54,000 kg of PGMs was recovered from catalytic converters in the United States, which was about 49% of the world total. The quantity of material available for recycling is very price sensitive. As metal prices increase, recycling becomes more profitable and, thus, more material is available for supply; conversely, a decrease in metal prices leads to reduced recycling and reduced material availability from recycling (Cowley, 2019, p. 35, 39, 43; CPM Group, 2019, p. 32–33, 119, 180).

Sibanye-Stillwater reported that it recovered 21,400 kg of PGMs from spent catalytic converters and other industrial sources in 2018. Of the total recycled, Sibanye-Stillwater toll-refined 4,480 kg of PGMs. In 2018, Sibanye-Stillwater sold 16,800 kg of PGMs (Sibanye Gold Ltd., 2019a, p. 50). In June, Heraeus Precious Metals North America LLC announced that it had expanded its precious-metals recycling plant in Wartburg, TN, to meet increasing demand. The expansion created 20 new jobs and included upgrades to recycling technologies and capabilities (International Precious Metals Institute, 2018).

## Consumption

The PGMs are consumed in several different industries in the United States and are often used in the same applications. Owing to similar atomic structures and chemistries, they exhibit similar properties, which include biocompatibility; catalytic, conductive, and electrical properties; high melting temperature; and resistance to chemical corrosion and oxidation. The primary uses for PGMs are in automotive catalytic converters, chemical and petroleum catalysts, electronics, glassmaking, investment, jewelry, and medical and dental devices.

The dominant application for PGMs since 1979 has been in catalytic converters. Palladium, platinum, and rhodium are used in catalytic converters to capture harmful exhaust emissions, such as carbon monoxide, hydrocarbons, and nitrogen oxides. The catalytic properties of the PGMs are also used in the chemical and petroleum industries. In the chemical industry, platinum and rhodium catalyze the reaction that generates nitric acid, which is used in the production of explosives, fertilizers, and some plastics. Additionally, platinum catalysts are necessary for the production of silicone. In the petroleum industry, platinum is used as a catalyst in the refining of crude oil, reforming, and other processes used in the production of aromatic compounds and high-octane gasoline.

Uses of the PGMs in electronics include hard-drive disks, multilayer ceramic capacitors, plasma-display panels, and semiconductor thermocouples. Iridium is used specifically as a crucible material for the production of high-quality single crystals. Owing to their resistance to chemical corrosion and degradation at high temperatures, platinum and rhodium are used in glassmaking primarily for manufacture of liquid-crystal displays. The biocompatibility (nonreactivity of the metals with organic tissue) of the PGMs allows for their use in dental and medical devices as well as in jewelry. Their resistance to chemical corrosion and oxidation and relative rarity on Earth also make them appealing for jewelry as well as physical investment in the form of coin and bullion.

**Palladium.**—In 2018, apparent domestic palladium consumption, defined as primary production plus secondary production plus imports minus exports, excluding imports and exports of waste and scrap, was 95,900 kg, an increase of 7% from 89,300 kg in 2017. The leading end use for palladium in 2018 was in the production of catalytic converters, which accounted for 71% of consumption in North America. Other uses, including chemical and petroleum catalysts, dental and medical devices, electronics, and jewelry, accounted for the remaining 28% (CPM Group, 2019, p. 119).

**Platinum.**—In 2018, apparent domestic platinum consumption, defined as mine production plus recycling plus imports minus exports, was 53,800 kg, an increase of 4% compared with apparent consumption in 2017. The leading end uses for platinum in 2018 were in the production of catalytic converters and in chemical and petroleum refining, which accounted for 57% and 20% of consumption in the United States, respectively. Other uses accounted for 23% and included dental and medical devices, electronics, and jewelry (CPM Group, 2019, p. 37).

**Other PGMs.**—In 2018, adequate data were not available to determine the apparent consumption of iridium, osmium, rhodium, or ruthenium.

## Prices

According to Platts Metals Week, the Engelhard unfabricated annual average prices for iridium, palladium, rhodium, and ruthenium in 2018 increased by 42%, 19%, 100%, and 218%, respectively, from those in 2017, whereas the price for platinum decreased by 7% (table 1). Figure 1 illustrates the average monthly prices from 2014 through 2018.

**Iridium.**—The annual average iridium price in 2018 was \$1,293.27 per troy ounce, which was 42% greater than that in 2017. The iridium price began the year at \$990 per troy ounce, where it remained until early March. The price then trended steeply upward from mid-April to late May and increased more gradually for the remainder of the year, ending the year at \$1,485 per troy ounce. The price increase for iridium in 2018 was attributed to an increase in demand for iridium-containing crucibles used by producers of lithium-tantalite crystal material, especially for components in smartphones (Heraeus Precious Metals GmbH & Co. KG, 2019, p. 10).

**Palladium.**—The annual average palladium price in 2018 was \$1,036.43 per troy ounce, which was 19% greater than that in 2017. The palladium price began 2018 at \$1,092 per troy ounce and fluctuated throughout the year with a general trend upward, ending the year at \$1,266 per troy ounce. The price increase for palladium in 2018 was reportedly the result of a limited supply with demand mostly from the automotive sector (Heraeus Precious Metals GmbH & Co. KG, 2019, p. 7).

**Platinum.**—In 2018, the annual average platinum price was \$882.66 per troy ounce, which was 7% less than that in 2017, continuing a downward trend that began in 2012 after a record high of \$1,725 per troy ounce in 2011. Platinum began the year at \$939 per troy ounce and fluctuated throughout the year, ending the year at \$790 per troy ounce. The price decrease for platinum in 2018 was largely owing to oversupply (Heraeus Precious Metals GmbH & Co. KG, 2019, p. 6).

**Rhodium.**—The annual average rhodium price in 2018 was \$2,225.30 per troy ounce, which was double that of 2017. The rhodium price began the year at \$1,725 per troy ounce and generally trended upward to the yearend price of \$2,460 per troy ounce. Exceptions included a notable trough from late April to mid-May and peaks from mid-September to late October and early November. The price increase for rhodium in 2018 was attributed to a limited supply and increased demand from the automotive sector (Heraeus Precious Metals GmbH & Co. KG, 2019, p. 8).

**Ruthenium.**—The annual average ruthenium price in 2018 was \$244.41 per troy ounce, which was 218% greater than that in 2017. The ruthenium price began the year at \$195 per troy ounce and increased gradually to \$275 per troy ounce by yearend. The price increase for ruthenium in 2018 was largely owing to increased manufacturing of ruthenium-bearing hard-drive disk and increased demand for nylon materials in China (Heraeus Precious Metals GmbH & Co. KG, 2019, p. 9).

## Foreign Trade

In 2018, imports for consumption of palladium, excluding waste and scrap, increased by 8% to 92,900 kg, from 86,000 kg in 2017. The imports were sourced predominantly from Russia (37%), South Africa (27%), Germany (17%), and Canada (7%). In 2018, imports for consumption of platinum, excluding waste and scrap, increased by 10% to 58,500 kg, from 53,200 kg in 2017. The leading sources of platinum imports were South Africa (44%), Germany (23%), Italy (6%), and Switzerland (6%). Imports for consumption of rhodium increased by 26% compared with 2017 to 14,500 kg; combined imports of iridium, osmium, and ruthenium increased by 12% to 18,900 kg. Leading import sources for iridium, osmium, rhodium, and ruthenium in 2018 were South Africa (51%), the United Kingdom (20%), Germany (19%), and Russia (5%) (tables 2, 3).

In 2018, exports of palladium, excluding waste and scrap, totaled 53,300 kg, a slight increase from 2017. Exports of platinum, excluding and waste and scrap, totaled 18,900 kg, a 14% increase compared with exports in 2017. Exports of rhodium and combined exports of iridium, osmium, and ruthenium more than doubled compared with exports in 2017 (tables 1, 4).

## World Review

In 2018, world mine production of PGMs increased by 3% to 471,000 kg from 456,000 kg (revised) in 2017 (table 5). South Africa accounted for the largest share of total PGM mine production in 2018 (58%), followed by Russia, 25%; Zimbabwe, 6%; Canada, 6%; the United States, 4%; and other countries, less than 2%. In 2018, world platinum mine production increased by 3% to 190,000 kg, with South Africa accounting for 72%; Russia, 12%; Zimbabwe, 8%; Canada, 4%; the United States, 2%, and other countries, 2%. Global mine production of palladium in 2018 increased slightly to 220,000 kg. Russia and South Africa accounted for 41% and 37%, respectively, of world palladium production in 2018; Canada, 9%; the United States, 6%; Zimbabwe, 5%; and other countries, 1%. World mine production of other PGMs (iridium, rhodium, and ruthenium) increased by 8% in 2018 compared with that of 2017, and South Africa accounted for 87% of global production.

**Belgium.**—Umicore N.V., a multinational materials technology company, expanded its precious-metals refining operations in Hoboken in response to increasing precious-metals demand in the global market. The increase in production was achieved in part through the addition of new employees at the Hoboken plant. Increased process volumes were also achieved despite a fire that broke out in the plant in September (Umicore N.V., 2019, p. 20, 37; undated).

**Canada.**—In October, North American Palladium Ltd. announced the results of a new feasibility study for its Lac des Iles Mine in northwestern Ontario. The report extended mine life by 1 year to 2027 with the average ore production rate doubling to 12,000 metric tons per day. In December, North American Palladium Ltd. announced that it had entered into a contract with mining engineering firm Redpath Canada Ltd. for a major expansion project for the Lac des Iles Mine. The mine development was predicted to take 2 years to complete (Decharte and others, 2018, p. 9; North American Palladium Ltd., 2018).

**China.**—On September 12, Heraeus Precious Metals GmbH & Co. KG announced the opening of its new precious-metals plant in Nanjing, Jiangsu Province. The facility would increase the company's precious-metals and chemical products refining and recycling capacities, especially for PGMs. Its recycling rate and chemical production capacity were expected to increase to 3,000 metric tons per year (t/yr) and threefold, respectively (Heraeus Precious Metals GmbH & Co. KG, 2018).

**Russia.**—In 2018, PJSC MMC Norilsk Nickel (Nornickel), a leading PGM producer in Russia, produced palladium and platinum at its two production assets in Russia—JSC Kolskaya Mining and Metallurgical Company (Kola MMC) on the Kola Peninsula and the Polar Division on the Taymyr Peninsula. Nornickel's PGM production decreased slightly compared with that in 2017 owing to a decrease in the amount of third-party material processed (PJSC MMC Norilsk Nickel, 2019b). In February, Nornickel and Russian Platinum LLC signed a deal to develop three PGM ore deposits in the Norilsk Industrial District in a 50–50 joint venture (PJSC MMC Norilsk Nickel, 2019a, p. 70). The three deposits would produce a combined 70 to 100 t/yr of PGMs, 50,000 t/yr of nickel, and 70,000 t/yr of copper. A feasibility study was scheduled to be completed by the end of 2019, with the project beginning in 2020 and the first salable material expected in 2023 (Faye, 2018; Russia & CIS Metals and Mining Weekly, 2018a; Zhukov, 2018).

In May, Nornickel announced plans to invest 25.7 billion rubles (more than \$400 million in May 2018) over 6 years (2018–2023) to upgrade its assets at Kola MMC. The primary goals included increasing efficiency, increasing the quality of production, and reducing emissions (Russia & CIS Metals and Mining Weekly, 2018b).

**South Africa.**—On April 2, six miners employed by African Rainbow Minerals Ltd. were killed on their way to the Modikwa Mine. Since the beginning of 2016, more than 400 incidents of social unrest took place in the eastern portion of South Africa's platinum belt, according to data from Anglo American Platinum Ltd. The incidents were reportedly linked to conflicts between rival unions and grievances over jobs and revenue flows (Stoddard, 2018a, b).

On August 2, Impala Platinum Holdings Ltd. (Implats) published a strategic review of its Rustenburg operations in South Africa aimed at ensuring long-term profitability. The strategy would involve decreasing the operational mine shafts from 11 to 6 and cutting 13,000 jobs over the next 2 years. Annual production after the changes to operations was estimated to be 16,000 kg of PGMs, down from the current production of about 23,000 kg of PGMs. Implats clarified that the changes would affect only its Rustenburg operations

and would not affect jobs at its mines in Zimbabwe (Impala Platinum Holdings Ltd., 2018).

Acquisitions of assets in South Africa that took place in 2018 included Northam Platinum Ltd.'s acquisition of Glencore plc's Eland platinum mine in January and Anglo American Platinum Ltd.'s acquisition of its joint-venture partners' shares in the Mototolo operations in November (Anglo American Platinum Ltd., 2018; International Mining, 2018). Another new PGM project, the Waterberg joint venture, was announced by Platinum Group Metals Ltd., and a mining rights application was accepted by the South African Department of Mineral Resources in October. Other partners involved in the venture included Implats, Mnombo Wethu Consultants (Pty) Ltd., the Japan Oil, Gas and Metals National Corporation, Hanwa Co. Ltd., and Hosken Consolidated Investments Ltd. (Platinum Group Metals Ltd., 2018a, b).

**United Kingdom.**—Vale S.A. closed its Acton PGM refinery as part of its business optimization strategy (Vale S.A., 2019, p. 59). The Acton facility had processed PGM intermediates and PGM feeds from third parties. Johnson Matthey Plc reported unscheduled downtime at its PGM refinery in the United Kingdom. The company reported that the downtime affected returns on investment and working capital (Johnson Matthey Plc, 2019, p. 11).

**Zimbabwe.**—In June, Zimplats Holdings Ltd. (a subsidiary of Implats) announced that it had agreed to release 23,903 hectares of mining claims back to the Government of Zimbabwe. In 2013, the Government planned to compulsorily acquire a portion of Zimplats' mining claims to allocate to other investors, which the company initially opposed. Karo Mining Holdings Ltd. was awarded mining rights to the land area (Tharisa plc, 2018; Zimplats Holdings Ltd., 2018).

The Government of Zimbabwe announced plans to construct a base- and precious-metals refinery that would be capable of processing all platinum material mined within the country. The Government also planned to place a 5% tax on exported platinum concentrates beginning in 2019 to encourage domestic refining (Thomson Reuters, 2018).

## Outlook

Palladium, platinum, and rhodium are used primarily in catalytic converters in automobiles to decrease harmful emissions; therefore, the performance of the gasoline and hybrid automobile industry, which requires catalytic converters, will have the greatest impact on future consumption of these PGMs. New environmental regulations on diesel vehicles in Europe and the move towards electric vehicles globally are likely to decrease the demand for PGMs in the long term. The development of hydrogen fuel cell vehicles, which use PGMs, is an additional factor.

PGM production levels from South Africa are expected to decrease slightly and will remain vulnerable to problems in the South African mining industry, including work stoppages caused by labor disputes and safety issues, ongoing restructuring of the platinum mining industry, and the closure of unprofitable mines. Supply from Zimbabwe is expected to increase owing to ongoing mine expansions but is subject to political stability.

Recycling of platinum and palladium is expected to increase, particularly from automotive catalysts.

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TABLE 1  
SALIENT PLATINUM-GROUP METALS STATISTICS<sup>1</sup>

		2014	2015	2016	2017	2018
United States:						
Mine production: <sup>2</sup>						
Palladium, Pd content:						
Quantity	kilograms	12,400	12,500	13,100	14,000 <sup>r, e</sup>	14,300
Value	thousands	\$324,000	\$280,000	\$259,000	\$380,000 <sup>r, e</sup>	\$639,000
Platinum, Pt content:						
Quantity	kilograms	3,660	3,670	3,890	4,000 <sup>r, e</sup>	4,160
Value	thousands	\$163,000	\$125,000	\$124,000	\$120,000 <sup>r, e</sup>	\$118,000
Refinery production: <sup>3</sup>						
Palladium, Pd content:						
Quantity	kilograms	42,700	38,300	43,800 <sup>r</sup>	38,000 <sup>r</sup>	26,600
Value	thousands	\$1,110,000	\$857,000	\$870,000	\$1,070,000 <sup>r</sup>	\$1,360,000
Platinum, Pt content:						
Quantity	kilograms	26,700	26,800	26,100	27,800 <sup>r</sup>	24,800
Value	thousands	\$1,190,000	\$911,000	\$832,000	\$850,000 <sup>r</sup>	\$704,000
Imports for consumption, refined:						
Iridium, Ir content	kilograms	1,960	1,010	1,300	1,420	1,020
Osmium, Os content	do.	322	8	27	856	25
Palladium, Pd content	do.	92,900	85,300	80,400	86,000	92,900
Platinum, includes coins, Pt content	do.	45,400 <sup>r</sup>	42,700 <sup>r</sup>	42,300 <sup>r</sup>	53,200 <sup>r</sup>	58,500
Rhodium, Rh content	do.	11,100	10,600	10,700	11,600	14,500
Ruthenium, Ru content	do.	11,000	8,230	8,410	14,600 <sup>r</sup>	17,900
Waste and scrap, Pt content	do.	112,000	123,000	154,000	354,000	40,700
Exports, refined:						
Iridium, osmium, and ruthenium, gross weight	do.	887	781	736	939	2,600
Palladium, Pd content	do.	22,100	23,000	17,500	52,300	53,300
Platinum, Pt content	do.	14,800	14,400	14,000	16,700	18,900
Rhodium, Rh content	do.	433	759	794	844	2,010
Waste and scrap, Pt content	do.	254,000	246,000	48,100	55,500	31,800
Stocks, National Defense Stockpile, December 31:						
Iridium, Ir content	do.	15	15	15	15	15
Platinum, Pt content	do.	261	261	261	261	261
Price, average: <sup>4</sup>						
Iridium	dollars per troy ounce	556.19	544.19	586.90	908.35	1,293.27
Palladium	do.	809.89	694.99	617.39	874.30	1,036.43
Platinum	do.	1,387.89	1,056.09	989.52	951.23	882.66
Rhodium	do.	1,174.23	954.90	696.84	1,112.59	2,225.30
Ruthenium	do.	65.13	47.63	42.00	76.86	244.41
Employment		1,620	1,440	1,430	1,510	1,630
World, mine production, PGM content	kilograms	382,000 <sup>r</sup>	470,000 <sup>r</sup>	460,000 <sup>r</sup>	456,000 <sup>r</sup>	471,000

<sup>e</sup>Estimated. <sup>r</sup>Revised. do. Ditto.

<sup>1</sup>Table includes data available through December 11, 2019. Data are rounded to no more than three significant digits, except prices.

<sup>2</sup>Source: Sibanye-Stillwater investor reports. Data for 2017 were partially estimated for the months prior to Sibanye Gold Ltd.'s acquisition of Stillwater Mining Co. in May 2017.

<sup>3</sup>Data revised based on new sources of information and publicly available reports.

<sup>4</sup>Price data are annual averages of daily Engelhard unfabricated quotations published in Platts Metals Daily.



TABLE 2  
U.S. IMPORTS FOR CONSUMPTION OF PLATINUM, BY COUNTRY OR LOCALITY<sup>1</sup>

Country or locality	Crain and nuggets		Sponge		Other unwrought		Semimanufactured forms		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)
2017	1,570 <sup>†</sup>	\$49,000	39,300	\$1,200,000	3,530	\$113,000	8,040	\$255,000	837	\$27,600
2018:										
Australia	--	--	--	--	--	--	(2)	21	161	4,880
Austria	--	--	--	--	--	--	104	3,010	45	1,350
Belgium	4	116	1,760	51,900	--	--	208	8,080	--	--
Brazil	--	--	--	--	--	--	1	41	--	--
Canada	84	2,420	--	--	89	3,250	486	14,700	745	22,000
China	--	--	--	--	--	--	(2)	8	2	37
Colombia	1	24	--	--	239	7,080	29	410	--	--
France	(2)	2	63	1,820	--	--	196	5,020	--	--
Germany	22	614	8,070	247,000	1,410	46,700	4,140	138,000	66	2,280
Italy	--	--	3,580	106,000	--	--	4	88	(2)	8
Japan	--	--	9	262	217	6,470	35	923	(2)	12
Korea, Republic of	--	--	546	16,000	--	--	(2)	14	--	--
Malaysia	--	--	--	--	--	--	--	--	1	20
Mexico	21	768	--	--	2	109	1	41	--	--
Norway	--	--	1,500	43,500	31	994	12	415	--	--
Russia	--	--	1,900	53,800	--	--	14	460	6	99
Singapore	--	--	--	--	515	20,000	306	11,000	--	--
South Africa	843	21,800	24,200	682,000	495	14,100	120	3,530	7	271
Sweden	--	--	--	--	(2)	5	--	--	--	--
Switzerland	--	--	523	15,000	311	9,490	2,410	67,900	3	171
Taiwan	--	--	--	--	--	--	(2)	8	--	--
United Kingdom	67	2,260	911	26,400	18	631	1,660	48,800	124	3,780
Other	1	29	114	2,890	35	1,090	54	1,930	2	42
Total	1,040	28,100	43,100	1,250,000	3,370	110,000	9,780	305,000	1,160	34,900

<sup>†</sup>Revised. -- Zero.

<sup>1</sup>Table includes data available through December 11, 2019. Data are rounded to no more than three significant digits; may not add to totals shown.

<sup>2</sup>Less than ½ unit.

Source: U.S. Census Bureau.

TABLE 3  
U.S. IMPORTS FOR CONSUMPTION OF PLATINUM-GROUP METALS, BY COUNTRY OR LOCALITY<sup>1</sup>

Country or locality	Palladium <sup>2</sup>		Iridium <sup>2</sup>		Osmium <sup>2</sup>		Ruthenium <sup>2</sup>		Rhodium <sup>2</sup>		Waste and scrap	
	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)	Quantity, Pt content (kilograms)	Value (thousands)
2017	86,000	\$2,400,000	1,420	\$38,100	856	\$1,740	14,600 <sup>r</sup>	\$34,200	11,600	\$386,000	354,000 <sup>r</sup>	\$1,050,000
2018:												
Algeria	--	--	--	--	--	--	--	--	--	--	114	3,260
Australia	--	--	--	--	--	--	--	--	--	--	23	746
Belgium	667	19,100	--	--	--	--	(3)	4	868	56,900	180	8,590
Brazil	--	--	--	--	--	--	--	--	--	--	941	30,400
Canada	6,450	241,000	--	--	--	--	--	--	15	476	4,710	120,000
China	(3)	2	9	417	25	136	--	--	--	--	5,890	31,400
Colombia	--	--	--	--	--	--	--	--	--	--	159	2,950
Czechia	158	4,950	--	--	--	--	20	49	--	--	5	189
France	(3)	21	--	--	--	--	--	--	--	--	1,250	19,500
Germany	15,700	541,000	116	4,340	--	--	3,370	26,200	2,830	212,000	4,870	188,000
Hong Kong	(3)	10	--	--	--	--	150	355	--	--	(3)	16
Italy	3,190	107,000	2	95	--	--	--	--	477	33,400	901	29,500
Japan	1,330	23,100	25	796	--	--	12	31	76	5,880	2,370	84,000
Korea, Republic of	98	2,970	--	--	--	--	--	--	32	2,390	124	3,760
Malaysia	--	--	--	--	--	--	--	--	--	--	357	7,840
Mexico	54	1,690	--	--	--	--	--	--	--	--	3,110	94,300
Netherlands	--	--	5	158	--	--	--	--	--	--	109	2,840
New Zealand	--	--	--	--	--	--	--	--	--	--	328	11,200
Norway	2,100	68,600	--	--	--	--	--	--	52	3,760	92	2,800
Poland	--	--	--	--	--	--	--	--	--	--	424	10,400
Qatar	--	--	--	--	--	--	--	--	--	--	567	18,500
Russia	34,300	1,130,000	33	953	--	--	513	4,150	1,100	74,600	--	--
Saudi Arabia	--	--	--	--	--	--	--	--	--	--	1,090	31,500
Singapore	--	--	--	--	--	--	--	--	--	--	4,110	130,000
Slovakia	--	--	--	--	--	--	--	--	--	--	172	5,370
South Africa	25,500	857,000	629	25,100	--	--	8,870	63,600	7,420	487,000	156	4,190
Sweden	--	--	--	--	--	--	--	--	--	--	144	7,830
Switzerland	1,480	49,000	--	--	--	--	--	--	--	--	--	--
Taiwan	145	3,910	--	--	--	--	116	737	--	--	367	11,300
United Kingdom	1,630	54,600	200	6,160	--	--	4,810	37,500	1,640	111,000	6,330	162,000
Other	91	3,020	--	--	--	--	--	--	--	--	1,770	41,500
Total	92,900	3,110,000	1,020	38,000	25	136	17,900	133,000	14,500	987,000	40,700	1,060,000

<sup>r</sup>Revised. -- Zero.

<sup>1</sup>Table includes data available through December 11, 2019. Data are rounded to no more than three significant digits; may not add to totals shown.

<sup>2</sup>Unwrought and other forms.

<sup>3</sup>Less than ½ unit.

Source: U.S. Census Bureau.

TABLE 4  
U.S. EXPORTS OF PLATINUM-GROUP METALS, BY COUNTRY OR LOCALITY<sup>1</sup>

Country or locality	Palladium		Platinum		Iridium, osmium, ruthenium		Rhodium		Waste and scrap	
	Quantity, Pd content	Value	Quantity, Pt content	Value	Quantity, gross weight	Value	Quantity, Rh content	Value	Quantity, Pt content	Value
	(kilograms)	(thousands)	(kilograms)	(thousands)	(kilograms)	(thousands)	(kilograms)	(thousands)	(kilograms)	(thousands)
2017	52,300	\$888,000	16,700	\$494,000	939	\$11,700	844	\$30,700	55,500 <sup>†</sup>	\$540,000 <sup>†</sup>
2018:										
Argentina	69	1,650	47	2,390	--	--	--	--	--	--
Australia	--	--	81	2,270	181	2,020	1	12	--	--
Austria	--	--	2	74	5	72	--	--	1	21
Belarus	32	354	--	--	--	--	--	--	--	--
Belgium	240	4,050	320	9,240	--	--	74	3,630	6,280	125,000
Brazil	437	13,700	91	2,720	1	6	20	950	--	--
Canada	2,130	53,200	206	7,000	2	35	1	107	183	2,050
China	2,940	88,900	332	9,360	136	3,470	270	16,200	--	--
Colombia	22	475	(2)	4	(2)	6	--	--	--	--
Costa Rica	181	1,680	284	3,830	8	41	--	--	--	--
Czechia	18	224	--	--	--	--	--	--	4	128
Denmark	17	294	1	23	--	--	--	--	--	--
France	351	3,220	41	1,290	27	302	(2)	4	--	--
Germany	16,500	299,000	7,340	224,000	218	2,840	271	17,800	8,640	91,900
Hong Kong	730	16,800	77	2,270	87	922	47	2,850	--	--
India	111	3,110	303	9,230	95	962	4	188	48	1,470
Ireland	221	2,190	284	8,140	4	14	--	--	--	--
Israel	2,090	16,400	8	200	(2)	13	--	--	--	--
Italy	2,520	76,200	81	2,580	34	774	52	2,900	2,060	72,400
Japan	1,690	44,900	2,580	74,400	1,380	24,600	495	31,400	629	20,300
Korea, Republic of	704	10,800	192	5,970	1	18	40	2,520	1	16
Laos	--	--	20	615	--	--	--	--	--	--
Mexico	243	2,910	252	8,100	11	150	3	365	--	--
Netherlands	18	112	3	148	13	347	--	--	--	--
New Zealand	27	566	3	106	--	--	--	--	--	--
Peru	9	154	3	110	--	--	--	--	--	--
Poland	6	49	5	107	(2)	7	--	--	--	--
Russia	--	--	23	971	--	--	--	--	--	--
Saudi Arabia	8	317	(2)	17	--	--	--	--	--	--
Singapore	193	6,570	660	20,900	--	--	25	1,660	--	--
South Africa	2	11	1	14	--	--	621	42,700	167	3,960
Spain	10	75	--	--	--	--	--	--	--	--
Switzerland	17,500	276,000	557	21,000	102	2,050	--	--	8,150	126,000
Taiwan	1,740	52,200	63	1,940	176	1,170	(2)	8	--	--
Thailand	405	3,620	36	1,050	--	--	1	57	4	120
Turkey	--	--	41	1,420	--	--	--	--	--	--
United Arab Emirates	5	122	2	61	--	--	--	--	--	--
United Kingdom	2,110	83,200	4,960	164,000	110	2,680	88	6,330	5,640	172,000
Uruguay	--	--	7	246	(2)	4	--	--	--	--
Vietnam	1	25	28	818	--	--	--	--	--	--
Other	30	535	19	599	3	29	(2)	18	--	--
Total	53,300	1,060,000	18,900	587,000	2,600	42,600	2,010	130,000	31,800	616,000

<sup>†</sup>Revised. -- Zero.

<sup>1</sup>Table includes data available through December 11, 2019. Data are rounded to no more than three significant digits; may not add to totals shown.

<sup>2</sup>Less than ½ unit.

Source: U.S. Census Bureau.

TABLE 5  
PLATINUM-GROUP METALS: WORLD MINE PRODUCTION, BY COUNTRY OR LOCALITY<sup>1</sup>

(Kilograms)

Country or locality <sup>2</sup>	2014	2015	2016	2017	2018
<b>Palladium:</b>					
Australia <sup>e,3</sup>	600	420	590	600	420
Botswana	1,120	930 <sup>e</sup>	-- <sup>e</sup>	-- <sup>e</sup>	-- <sup>e</sup>
Canada <sup>e</sup>	23,000 <sup>r</sup>	24,000 <sup>r</sup>	22,000 <sup>r</sup>	19,000 <sup>r</sup>	20,000
China	830 <sup>r,e</sup>	1,200	1,400 <sup>r</sup>	1,400	1,300
Finland	808	784	901	1,021	1,157
Russia <sup>e</sup>	86,000 <sup>r</sup>	85,000 <sup>r</sup>	83,000 <sup>r</sup>	88,000 <sup>r</sup>	90,000
Serbia	23	31	31	38	38 <sup>e</sup>
South Africa	58,410	82,691	76,273	80,132 <sup>r</sup>	80,629
United States <sup>4</sup>	12,400	12,500	13,100	14,000 <sup>r,e</sup>	14,300
Zimbabwe	10,138	10,055	12,222	11,822 <sup>r</sup>	12,000 <sup>e</sup>
<b>Total</b>	<b>193,000</b>	<b>218,000<sup>r</sup></b>	<b>209,000<sup>r</sup></b>	<b>216,000<sup>r</sup></b>	<b>220,000</b>
<b>Platinum:</b>					
Australia <sup>e,3</sup>	170	120	170	170	120
Botswana	249	190 <sup>e</sup>	-- <sup>e</sup>	-- <sup>e</sup>	-- <sup>e</sup>
Canada <sup>e</sup>	7,200 <sup>r</sup>	8,600 <sup>r</sup>	8,400 <sup>r</sup>	7,600 <sup>r</sup>	7,400
China	1,600	2,300	2,900 <sup>r</sup>	2,500	2,500
Colombia	1,142	861	917	566	269
Ethiopia <sup>e</sup>	--	5	5	5	5
Finland	1,060	992	1,178	1,418	1,576
Russia <sup>e</sup>	23,000	23,000 <sup>r</sup>	22,000 <sup>r</sup>	22,000 <sup>r</sup>	22,000
Serbia	3	4	4	2	2 <sup>e</sup>
South Africa	93,991	139,125	133,241	131,242 <sup>r</sup>	137,053
United States <sup>4</sup>	3,660	3,670	3,890	4,000 <sup>r,e</sup>	4,160
Zimbabwe	12,483	12,564	15,110	14,257 <sup>r</sup>	15,000 <sup>e</sup>
<b>Total</b>	<b>145,000<sup>r</sup></b>	<b>191,000<sup>r</sup></b>	<b>188,000<sup>r</sup></b>	<b>184,000<sup>r</sup></b>	<b>190,000</b>
<b>Iridium:</b>					
Canada <sup>e</sup>	200	100	300	200	200
Russia <sup>e</sup>	200	200	200	300	200
South Africa	4,231	6,230	6,624	5,973	6,357
Zimbabwe	544	507	598	619	540 <sup>e</sup>
<b>Total</b>	<b>5,180</b>	<b>7,040</b>	<b>7,720</b>	<b>7,090</b>	<b>7,300</b>
<b>Rhodium:</b>					
Canada <sup>e</sup>	600	600	600	60	400
Russia	2,830	2,613	2,644	2,115	2,700 <sup>e</sup>
South Africa	12,916	18,722	19,237	18,431	18,608
Zimbabwe	1,140	1,128	1,322	1,283	1,300 <sup>e</sup>
<b>Total</b>	<b>17,500</b>	<b>23,100</b>	<b>23,800</b>	<b>21,900</b>	<b>23,000</b>
<b>Ruthenium:</b>					
Canada <sup>e</sup>	200	300	300	500	300
Russia <sup>e</sup>	1,000	1,000	1,000	1,000	1,000
South Africa	18,896	28,747	28,278	24,486	27,999
Zimbabwe	983	977	1,174	1,102	1,200 <sup>e</sup>
<b>Total</b>	<b>21,100</b>	<b>31,000</b>	<b>30,800</b>	<b>27,100</b>	<b>30,500</b>
<b>Grand total</b>	<b>382,000<sup>r</sup></b>	<b>470,000<sup>r</sup></b>	<b>460,000<sup>r</sup></b>	<b>456,000<sup>r</sup></b>	<b>471,000</b>

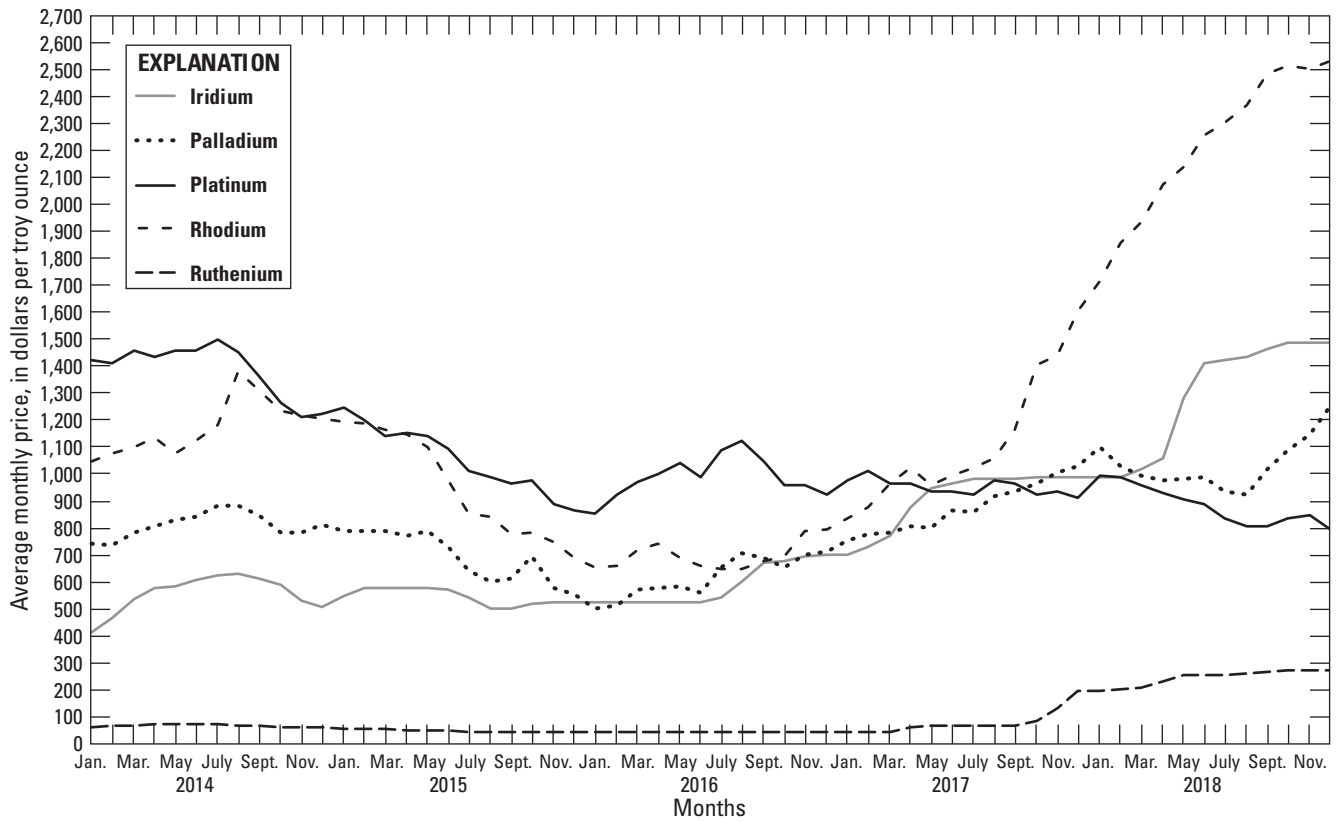
<sup>e</sup>Estimated. <sup>r</sup>Revised. -- Zero.

<sup>1</sup>Table includes data available through August 1, 2019. All data are reported unless otherwise noted. Totals, U.S. data, and estimated data are rounded to no more than three significant digits; may not add to totals shown.

<sup>2</sup>In addition to the countries and (or) localities listed, Indonesia and the Philippines may have produced limited quantities of platinum-group metals (PGMs), but available information was inadequate to make reliable estimates of output.

<sup>3</sup>PGMs recovered from nickel ore. PGMs in exported nickel ore are refined in importing countries, such as Japan and Poland.

<sup>4</sup>Byproduct platinum and palladium produced from gold-copper and nickel ores were excluded.



**Figure 1.** Engelhard unfabricated average monthly prices for platinum-group metals (iridium, palladium, platinum, rhodium, and ruthenium), 2014–18. Source: Platts Metals Week.