



2017 Minerals Yearbook

PLATINUM-GROUP METALS [ADVANCE RELEASE]

PLATINUM-GROUP METALS

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In 2017, the United States was the world's fourth-leading producer of palladium and the fifth-leading producer of platinum. Sibanye Gold Ltd. (Sibanye-Stillwater), 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 13,600 kilograms (kg) and 3,980 kg, a 4% and slight increase, respectively, from that of 2016 (estimated from partial year data reported in Sibanye Gold Ltd., 2018b, p. 12). Recycling was a significant source of PGMs as well, accounting for about 24% of the total global supply of palladium, platinum, and rhodium in 2017 (Cowley, 2018, p. 32, 36, 40; CPM Group, 2018, p. 7, 101, 165).

In 2017, the automobile industry continued to be the major consumer of PGMs. Catalytic converters accounted for approximately 82% of global rhodium consumption, 76% of palladium consumption, and 44% of platinum consumption (Cowley, 2018, p. 3, 19, 27; CPM Group, 2018, p. 7, 101, 165). The annual average prices for iridium, palladium, rhodium, and ruthenium increased by 55%, 42%, 60%, and 83%, respectively, compared with those of 2016, and the platinum price decreased by 4% (fig. 1, table 1). In 2017, excluding platinum waste and scrap, imports of PGMs increased by 17%, and exports increased by 114%. Note that the latter includes iridium, osmium, and ruthenium in gross weight (table 1). Most of the world's supply of primary PGMs came from South Africa and Russia, which accounted for 58% and 23%, respectively, of global primary PGM production. World mine production of PGMs totaled 489,000 kg, a 5% increase from the revised total in 2016 (table 5).

The 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.

Legislation and Government Programs

The Defense Logistics Agency Strategic Materials, Department of Defense, reported no PGM sales from U.S. Government stockpiles in 2017; 15 kg of iridium, 261 kg of platinum, and less than 1 kg each of palladium and palladium-cobalt wire remained in the stockpile. In addition, 8 kg of PGM compounds were added to the stockpile in 2017.

Production

Mine.—During 2017, U.S. palladium and platinum mine production was 13,600 kg and 3,980 kg, respectively, estimated on the basis of partial year data. Compared with 2016, this represented an increase of 4% for palladium and a slight increase for platinum (table 1). In May 2017,

Sibanye Gold Ltd. (South Africa) acquired Stillwater Mining Company (SMC) (Littleton, CO), and the company was rebranded Sibanye-Stillwater in August for trading purposes, though the legal name remained Sibanye Gold Ltd. SMC, founded in 1992, had been in business for 25 years and was the only U.S.-based company that mined PGMs domestically. Any subsequent discussion that cites Sibanye-Stillwater reports is only for production after May 2017 and will not add to equal previously presented data or that in table 1 (Sibanye Gold Ltd., 2017b, e).

Sibanye-Stillwater produced PGMs from two mines in the United States, the Stillwater Mine and the East Boulder Mine, both located in Montana. In 2017, the Stillwater Mine produced 8,970 kg of PGMs, and the East Boulder Mine produced 4,610 kg of PGMs. Sibanye-Stillwater processed 855,000 metric tons (t) of ore from the mines with a combined mill-head grade of 15 grams per metric ton (g/t) 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., 2018a, p. 36, 38, 229).

At yearend 2017, Sibanye-Stillwater reported proven and probable reserves at its Montana mines of 41.8 million metric tons (Mt) of ore with a palladium-to-platinum ratio ranging from 3.4:1 to 3.6:1 and about 681,000 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., 2018a, p. 262–263). In September 2017, Sibanye-Stillwater reported the first production from its Blitz development project, a mine expansion project adjacent to the Stillwater Mine. Ore removed during excavation, totaling 1,360 t, was stockpiled and processed. Full production from the Blitz project was expected by late 2020 to early 2021 and would be about 9,330 kg of palladium and platinum, expanding Sibanye-Stillwater's U.S. production capacity by more than 50% (Sibanye Gold Ltd., 2017d).

In addition to the mine production from Sibanye-Stillwater's mines, PGMs are also recovered as a byproduct of nickel from Lundin Mining Corp.'s (Canada) Eagle Mine in Michigan. Data were not available to make estimates for this production, however. In 2017, two PGM exploration projects in the Duluth Complex of Minnesota continued to progress towards development. PolyMet Mining Corp. (Canada) continued the permitting process to begin to construct and operate the NorthMet project in northeastern Minnesota. The NorthMet project, planned as an open pit mine, would produce cobalt, copper, gold, nickel, palladium, platinum, and silver.

The ore would be processed at the company's nearby Erie Plant facilities, originally used to process iron ore (PolyMet Mining Corp., 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. On January 13, 2017, Twin Metals was notified that the U.S. Forest Service and the Bureau of Land Management were withdrawing Federal land in northeastern Minnesota from future development, exploration, or leasing. Twin Metals was pursuing legal avenues seeking to secure its rights to its two Federal mining leases (Twin Metals Minnesota LLC, 2017).

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 for 2017, 8 companies responded. The amount of refinery production by the companies that did not respond to the survey was estimated on the basis of prior reports or on information from other sources; however, it was likely underestimated. Data for the 5 years presented in table 1 were revised for both palladium and platinum refinery production on the basis of new sources of publicly available information.

During 2017, U.S. palladium and platinum refinery production were 42,500 kg and 27,600 kg, respectively. Compared with the revised data for 2016, this represented a decrease of 3% for palladium and an increase of 6% for platinum (table 1).

Recycling.—In 2017, PGMs were recycled from three main sources—catalytic converters, electronics, and jewelry. Globally, more than 137,000 kg of secondary PGMs were recovered, accounting for approximately 24% of the global supply of PGMs. Catalytic converters were the predominant source of secondary PGMs. An estimated 55,000 kg of PGMs was recovered from catalytic converters in the United States, which was about 50% 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, 2018, p. 32, 36, 40; CPM Group, 2017, p. 190; 2018, p. 7, 28, 101, 113, 165).

From its acquisition of SMC in May 2017 to yearend, Sibanye-Stillwater reported that it recovered 16,100 kg of PGMs from spent catalytic converters and other industrial sources in 2017. Of the total recycled PGMs, Sibanye-Stillwater toll refined 3,380 kg. In 2017, Sibanye-Stillwater sold 11,800 kg of PGMs (Sibanye Gold Ltd., 2018a, p. 36).

Consumption

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 includes hard-drive disks, multilayer ceramic capacitors, plasma-display panels, and semiconductor thermocouples. Iridium is used specifically in crucibles 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-display computer monitors and television screens. 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 coins and bullion.

Palladium.—In 2017, apparent domestic palladium consumption, defined as mine production plus recycling plus imports minus exports, from trade data excluding waste and scrap, was 88,700 kg, a 25% decrease from the 118,000 kg in 2016. The leading end use for palladium in 2017 was 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 29% (CPM Group, 2018, p. 117).

Platinum.—In 2017, apparent domestic platinum consumption was 50,700 kg, a 19% increase from the 42,500 kg in 2016. The leading end uses for platinum in 2017 were the production of catalytic converters and chemical and petroleum refining, which accounted for 57% and 21% of consumption in the United States, respectively. Other uses accounted for 22% and included dental and medical devices, electronics, and jewelry (CPM Group, 2018, p. 33).

Other PGMs.—In 2017, adequate data were not available to determine the apparent consumption of iridium, osmium, rhodium, or ruthenium.

Prices

According to Platts Metals Daily, in 2017, the Engelhard unfabricated annual average prices for iridium, palladium, rhodium, and ruthenium increased by 55%, 42%, 60%, and 83%, respectively. The price for platinum decreased by 4% from 2016 (table 1). Figure 1 illustrates the average monthly prices from 2013 through 2017 for the PGMs.

Iridium.—The annual average iridium price in 2017 was \$908.35 per troy ounce, which was 55% greater than that in 2016 (table 1). The iridium price began the year at \$700 per troy ounce, where it remained until late January. The price then increased to \$990 per troy ounce in mid-August and again in October; it remained at \$990 per troy ounce until yearend. The price increase for iridium in 2017 was attributed to an increase in demand for iridium-containing electrode coatings used in industrial electrolysis applications owing to plant upgrades (Heraeus Precious Metals GmbH & Co. KG, 2018, p. 11).

Palladium.—The annual average palladium price in 2017 was \$874.30 per troy ounce, which was 42% greater than that in 2016. The palladium price began 2017 at \$710 per troy ounce, fluctuated throughout the year with a general trend upward, and ended the year at \$1,060 per troy ounce. The price increase for palladium in 2017 was reportedly the result of increased demand from the automotive sector in China (Heraeus Precious Metals GmbH & Co. KG, 2018, p. 8).

Platinum.—In 2017, the annual average platinum price was \$951.23 per troy ounce, which was 4% less than that of 2016, 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 \$931 per troy ounce and fluctuated throughout the year, ending the year at \$940 per troy ounce.

Rhodium.—The annual average rhodium price in 2017 was \$1,112.59 per troy ounce, which was 60% greater than that in 2016. The rhodium price began the year at \$765 per troy ounce and generally trended upward until mid-October, when it began to increase sharply from about \$1,260 per troy ounce to \$1,675 per troy ounce in late October. The price then decreased sharply to \$1,300 per troy ounce in mid-November and increased sharply to about \$1,500 per troy ounce several days later. It remained stable around \$1,550 per troy ounce until mid-December when it increased to around \$1,700 per troy ounce. The yearend price was \$1,725 per troy ounce. Similar to palladium, the price increase for rhodium in 2017 was attributed to increased demand from the automotive sector in China (Heraeus Precious Metals GmbH & Co. KG, 2018, p. 9).

Ruthenium.—The annual average ruthenium price in 2017 was \$76.86 per troy ounce, which was 83% greater than that in 2016, reversing the downward trend that had lasted from 2010 until 2016. The ruthenium price began the year at \$42 per troy ounce, increased gradually to \$66 per troy ounce from late March to late April where it remained until late September. From late September until early December, the price increased to \$195 per troy ounce where it essentially remained until the end of the year. The last time ruthenium's price was at these levels was in 2010 when it surpassed \$200 per troy ounce. The price increase for ruthenium in 2017 was likely a result of speculative buying of, and investment in, the metal, based on work done at the Ulsan National Institute of Science and Technology (UNIST) in the Republic of Korea. Researchers at UNIST created a ruthenium-based catalyst that performs as well as platinum at splitting water atoms into hydrogen. This is significant for the hydrogen fuel-cell industry as ruthenium has been much less costly than platinum (Ulsan National Institute of Science and Technology, 2017; Heraeus Precious Metals GmbH & Co. KG, 2018, p. 10).

Foreign Trade

In 2017, imports for consumption of refined palladium totaled 86,000 kg, a 7% increase from that of 2016. Imports of refined palladium in 2017 were sourced predominantly from Russia (36%), South Africa (35%), Germany (7%), and Canada (5%). In 2017, imports for consumption of platinum, excluding waste and scrap, increased by 26% to 53,200 kg, from 42,300 kg in 2016. Excluding waste and scrap, the leading sources of platinum imports in 2017 were South Africa (54%), Germany (19%), the United Kingdom (7%), and Italy (5%). Imports for consumption of rhodium increased by 8% compared with those in 2016 to 11,600 kg; combined imports of iridium, osmium, and ruthenium increased by 72% to 16,800 kg. Leading import sources for iridium, osmium, rhodium, and ruthenium in 2017 were South Africa (57%), Germany (16%), the United Kingdom (16%), and Russia (5%) (tables 2, 3).

In 2017, exports of refined palladium totaled 52,300 kg, a 200% increase from that of 2016. Exports of platinum increased by 19% and those of waste and scrap decreased by 26% compared with those in 2016. Exports of rhodium increased by 6% compared with exports in 2016, and combined exports of iridium, osmium, and ruthenium increased by 28% during the same time period (table 4).

World Review

In 2017, world mine production of PGMs increased by 5% to 489,000 kg from 467,000 kg in 2016 (table 5). South Africa accounted for 58% of total PGM mine production in 2017; Russia accounted for 23%; Canada, 6%; Zimbabwe, 6%; the United States, 4%, and other countries, 3%. In 2017, world platinum mine production increased by 4% to 199,000 kg with South Africa accounting for 72%; Russia, 11%; Zimbabwe, 7%; Canada, 5%; the United States, 2%, and other countries, 3%. Global mine production of palladium in 2017 increased by 8% to 226,000 kg. Russia and South Africa each accounted for 38% of world palladium production in 2017; Canada accounted for 8%; the United States, 6%; Zimbabwe, 5%; and other countries, 5%. World mine production of other PGMs (iridium, osmium, rhodium, and ruthenium) decreased by 3% in 2017 compared with that of 2016, and South Africa accounted for 84% of global production.

Canada.—North American Palladium Ltd. produced 6,270 kg of palladium and 382 kg of platinum from its Lac des Isles Mine in northwestern Ontario, increases of 35% and 20%, respectively, compared with production in 2016. The increase in production was a result of full-time milling operations resuming by the fourth quarter of 2017, following changes in mining methods and upgrades to infrastructure and equipment. In May, North American Palladium announced an update to its mineral resources and reserves estimates for the Lac des Isles Mine. The mineral reserves were increased to 38.5 Mt containing 86,600 kg of palladium and 8,470 kg of platinum, assuming average grades of 2.25 g/t palladium and 0.22 g/t platinum. These represented increases of 89% in total reserves, 100% in palladium content, and 131% in platinum content (Peck and others, 2015, p. 15-4; North American Palladium Ltd.,

2017). A feasibility report published in June 2017 reported an extension to the life-of-mine estimate to 9.5 years with expected palladium production of about 6,840 kilograms per year. In June, North American Palladium entered into an option agreement with Impala Platinum Holdings Ltd. (Implats) and Transition Metals Corp. to acquire a 75% ownership share of the Sunday Lake project located near Thunder Bay in Ontario. North American Palladium began its first drilling program at Sunday Lake in the second half of 2017 (North American Palladium Ltd., 2018, p. 2, 3, 9, 19).

Vale S.A. (Brazil) produced 6,660 kg of palladium and 4,480 kg of platinum as byproducts of its nickel operations at Sudbury, Ontario, decreases of 34% and 13%, respectively, from production in 2016. Glencore plc (Switzerland) produced PGMs as byproducts from its nickel mining operations at Sudbury and at the Raglan Mine in Quebec. In 2017, it produced 4,230 kg of palladium and 2,330 kg of platinum, representing decreases of 21% and 17%, respectively, compared with production in 2016. PGM production decreased owing to decreases in nickel production, which was a result of Glencore's increase in the proportion of feed from third parties rather than owned sourced material (Glencore plc, 2018, p. 70–71; Vale, S.A., 2018, p. 55).

Russia.—In 2017, PJCS MMC Norilsk Nickel, the dominant producer in Russia, produced 85,200 kg of palladium and 20,500 kg of platinum at its two production assets in Russia—Kola MMC on the Kola Peninsula and the Polar Division on the Taymyr Peninsula. Production increased by 7% for palladium and 6% for platinum compared with production in 2016 (PJSC MMC Norilsk Nickel, 2018).

South Africa.—The world's leading PGM producer, Anglo American Platinum Ltd. (Amplats), reported primary equivalent refined production of 30,100 kg for palladium and 41,700 kg for platinum in 2017, decreases of 6% and 17%, respectively, compared with production in 2016. Amplats' Bokoni Mine was placed on care-and-maintenance status in the third quarter of 2017, and the jointly owned Mototolo Mine was temporarily closed from August to December for safety work (Anglo American Platinum Ltd., 2018, p. 7, 12, 39, 48).

Glencore produced PGMs at its jointly owned Mototolo Mine in South Africa. Glencore also produced PGMs at Eland Mine prior to Northam Platinum's acquisition of it in February 2017. In 2017, Glencore produced 778 kg of palladium and 1,280 kg of platinum, which represented decreases of 31% and 29%, respectively. The unplanned stoppage at the Mototolo Mine from August to December for safety work contributed to these decreases (Glencore plc, 2018, p. 70–71). In August 2017, Glencore was reported to be in advanced discussions with Amplats concerning the sale of its shares of the Mototolo joint venture (Secombe, 2017).

Production at Implats' South African mining operations in 2017 was about 15,200 kg of palladium and 26,300 kg of platinum, essentially unchanged for palladium and a 5% decrease for platinum compared with production in 2016. The decrease in platinum production was largely owing to stoppages for safety work at the Rustenburg operations and protests that affected operations at the Marula Mine (Impala Platinum

Holdings Ltd., 2017a, p. 50, 52, 147, 154, 160; 2017b, p. 47, 49, 55; 2018, p. 49, 53, 57).

Lonmin plc (United Kingdom) produced 20,300 kg of palladium and 9,430 kg of platinum in 2017, a slight increase for palladium and essentially unchanged for platinum from the amounts produced in 2016. As of December 1, 2017, Lonmin owned 100% of the Pandora Mine, formerly a joint venture with Amplats (Lonmin plc, 2017a, p. 12; 2017b; 2017c, p. 6; 2017d, p. 8; 2018, p. 7). On December 14, 2017, Sibanye-Stillwater announced a proposition to acquire Lonmin. In doing so, it would become the world's second-leading platinum producer. Lonmin had mining operations at Marikana and Pandora in South Africa, exploration and development projects at Akanani in South Africa and the Sudbury Basin in Canada (in the form of three joint ventures), and processing facilities at Marikana and Brakpan in South Africa (Sibanye Gold Ltd., 2017c).

In 2017, Sibanye-Stillwater's South African mining operations produced 11,600 kg of palladium, a 173% increase compared with that in 2016, and 21,600 kg of platinum, a 187% increase. The substantial increases were a result of full production at all of Sibanye-Stillwater's South African PGM-producing mines in 2017. The Kroondal, Mimosa, and Platinum Mile Mines were acquired from Aquarius Platinum Ltd.'s shares in joint ventures in April 2016, and the Rustenburg Mine was acquired from Amplats in November 2016 (Sibanye Gold Ltd., 2017a, p. 6; 2018b, p. 12).

Zimbabwe.—Zimplats Holdings Ltd. (a subsidiary of Implats) produced 7,270 kg of palladium and 8,720 kg of platinum at its mining operations in Zimbabwe in 2017, 3% and 6% less, respectively, than production in 2016. The redevelopment of the Bimha Mine was on schedule and expected to return to full capacity by the fourth quarter of 2018. On January 13, the Government of Zimbabwe gave notice of its intent to compulsorily acquire 50% of Zimplats' remaining land on its mining lease. Zimplats submitted an objection, and the case was sent to court. The disagreement was not resolved by the end of 2017 (Impala Platinum Holdings Ltd., 2017a, p. 27, 100, 151; 2017b, p. 51; 2018, p. 51).

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. An increase in global automobile production in emerging markets, such as China and India, as well as in developed markets in the United States and Europe, will likely increase the demand for PGMs. However, 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, expected to decrease slightly, will remain vulnerable to problems in the South African mining industry, including work stoppages caused

by labor disputes and safety issues, and ongoing restructuring of the platinum mining industry, including closure of unprofitable mines. The 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 STATISTICS¹

		2013	2014	2015	2016	2017
United States:						
Mine production: ²						
Palladium, Pd content:						
Quantity	kilograms	12,600	12,400	12,500	13,100	13,600 ^e
Value	thousands	\$295,000	\$324,000	\$280,000	\$259,000	\$382,000 ^e
Platinum, Pt content:						
Quantity	kilograms	3,720	3,660	3,670	3,890	3,980 ^e
Value	thousands	\$178,000	\$163,000	\$125,000	\$124,000	\$122,000 ^e
Refinery production: ³						
Palladium, Pd content:						
Quantity	kilograms	45,700 ^r	42,700 ^r	38,300 ^r	43,900 ^r	42,500
Value	thousands	\$1,070,000 ^r	\$1,110,000 ^r	\$857,000 ^r	\$870,000 ^r	\$1,200,000
Platinum, Pt content:						
Quantity	kilograms	28,800 ^r	26,700 ^r	26,800 ^r	26,100 ^r	27,600
Value	thousands	\$1,380,000 ^r	\$1,190,000 ^r	\$911,000 ^r	\$832,000 ^r	\$845,000
Imports for consumption, refined:						
Iridium, Ir content	kilograms	1,740	1,960	1,010	1,300	1,420
Osmium, Os content	do.	77	322	8	27	856
Palladium, Pd content	do.	83,100	92,900	85,300	80,400	86,000
Platinum, includes waste, scrap, and coins, Pt content	do.	116,000	157,000	166,000	201,000	416,000
Rhodium, Rh content	do.	11,100	11,100	10,600	10,700	11,600
Ruthenium, Ru content	do.	15,400	11,000	8,230	8,410	14,500
Exports, refined:						
Iridium, osmium, and ruthenium, gross weight	do.	1,330	887	781	736	939
Palladium, Pd content	do.	25,900	22,100	23,000	17,500	52,300
Platinum, Pt content	do.	11,100	14,800	14,400	14,000	16,700
Rhodium, Rh content	do.	1,220	433	759	794	844
Stocks, National Defense Stockpile, December 31:						
Iridium, Ir content	do.	18	15	15	15	15
Platinum, Pt content	do.	261	261	261	261	261
Price, average: ⁴						
Iridium	dollars per troy ounce	826.45	556.19	544.19	586.90	908.35
Palladium	do.	729.58	809.89	694.99	617.39	874.30
Platinum	do.	1,489.57	1,387.89	1,056.09	989.52	951.23
Rhodium	do.	1,069.10	1,174.23	954.90	696.84	1,112.59
Ruthenium	do.	75.63	65.13	47.63	42.00	76.86
Employment		1,770	1,620	1,440	1,430	1,510
World, mine production, PGM content	kilograms	459,000 ^r	391,000 ^r	477,000 ^r	467,000 ^r	489,000

^eEstimated. ^rRevised. do. Ditto.

¹Table includes data available through August 17, 2018. Data are rounded to no more than three significant digits, except prices.

²Source: 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.

³Data revised based on new sources of information and publicly available reports.

⁴Price 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 LOCALITY¹

Country or locality	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)
2016	419	\$12,600	27,400	\$871,000	4,970	\$162,000 ^r	8,600 ^r	\$279,000	159,000	\$821,000	924	\$31,900
2017:												
Australia	--	--	--	--	(2)	2	(2)	16	472	8,490	215	6,990
Bahrain	--	--	--	--	--	--	--	--	188	5,070	--	--
Belgium	--	--	1,630	50,300	--	--	(2)	8	49	1,580	--	--
Brazil	--	--	--	--	--	--	4	122	2,100	29,400	--	--
Canada	43	1,300	--	--	(2)	6	332	10,600	21,900	73,200	596	19,500
China	--	--	--	--	--	--	51	2,220	20,700	21,100	(2)	6
Colombia	--	--	--	--	606	17,300	(2)	6	146	2,420	--	--
Czechia	--	--	--	--	--	--	245	7,300	--	--	--	--
France	--	--	72	2,190	8	232	155	5,510	716	16,400	--	--
Germany	101	3,160	3,640	119,000	1,500	51,600	5,010	161,000	34,700	244,000	(2)	17
Italy	--	--	2,800	87,400	1	40	2	91	1,070	40,300	--	--
Japan	280	8,650	88	2,630	193	5,950	198	6,010	2,590	74,900	--	--
Macau	--	--	--	--	--	--	--	--	2,710	410	--	--
Malaysia	--	--	--	--	--	--	--	--	806	12,700	--	--
Mexico	(2)	13	--	--	12	358	1	13	1,720	39,900	--	--
Netherlands	--	--	--	--	--	--	--	--	134	920	--	--
Norway	--	--	389	11,000	--	--	2	86	--	--	--	--
Panama	--	--	--	--	--	--	--	--	369	474	--	--
Poland	--	--	--	--	--	--	--	--	284	8,880	--	--
Qatar	--	--	--	--	--	--	--	--	3,690	113,000	--	--
Russia	463	14,400	1,010	30,700	--	--	--	--	--	--	--	--
Saudi Arabia	--	--	--	--	--	--	--	--	1,810	56,200	--	--
Singapore	--	--	--	--	5	183	145	4,990	3,240	101,000	--	--
South Africa	670	21,000	26,900	809,000	1,100	33,600	--	--	140	4,170	4	300
Sweden	--	--	--	--	--	--	--	--	6,090	4,690	--	--
Switzerland	--	--	223	7,130	76	2,360	677	20,200	--	--	--	--
Taiwan	--	--	--	--	--	--	108	3,510	374	10,100	--	--
Trinidad and Tobago	--	--	--	--	--	--	--	--	111	3,570	--	--
United Kingdom	16	479	2,480	78,100	1	50	1,030	31,800	256,000	153,000	6	243
Venezuela	--	--	--	--	1	36	--	--	212	6,530	--	--
Other	2	52	53	1,670	22	960	74	1,870	506	12,800	15	507
Total	1,580	49,000	39,300	1,200,000	3,530	113,000	8,040	2,555,000	363,000	1,050,000	837	27,600

^rRevised. -- Zero.

¹Table includes data available through August 17, 2018. Data 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.

TABLE 3
U.S. IMPORTS FOR CONSUMPTION OF PLATINUM-GROUP METALS, BY COUNTRY OR LOCALITY¹

Country or locality	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)
2016	68,100	\$1,340,000	12,300	\$275,000	1,300	\$23,000	27	\$159	8,410	\$14,500	10,700	\$230,000
2017:												
Argentina	--	--	4	101	--	--	--	--	--	--	1	25
Austria	--	--	93	2,900	--	--	--	--	--	--	--	--
Belgium	498	13,300	--	--	41	969	--	--	325	651	629	22,300
Canada	719	26,600	3,390	119,000	--	--	--	--	--	--	11	460
China	--	--	80	518	2	17	50	273	--	--	(3)	12
Czechia	--	--	(3)	3	--	--	10	58	5	16	--	--
Germany	6,140	206,000	233	5,550	98	2,620	--	--	3,800	8,810	633	30,600
India	--	--	12	294	--	--	--	--	--	--	--	--
Ireland	(3)	3	16	303	--	--	--	--	--	--	--	--
Italy	3,030	83,400	128	3,180	15	416	--	--	--	--	313	11,000
Japan	1,280	13,100	7	98	72	1,690	--	--	70	196	(3)	6
Korea, Republic of	162	4,670	(3)	9	--	--	--	--	--	--	33	978
Mexico	(3)	2	14	146	3	24	--	--	--	--	--	--
Norway	3,220	91,200	--	--	--	--	--	--	--	--	118	3,860
Russia	26,500	731,000	4,030	106,000	38	971	19	140	230	621	1,120	36,000
South Africa	28,900	782,000	1,540	41,700	841	22,500	774	1,250	7,290	17,900	7,160	233,000
Switzerland	730	19,000	1,450	38,000	--	--	--	--	--	--	28	944
Taiwan	132	3,830	--	--	--	--	--	--	--	--	--	--
Thailand	--	--	1	30	--	--	--	--	17	34	--	--
United Kingdom	3,700	110,000	46	1,610	311	8,880	3	21	2,760	6,050	1,510	47,600
Other	(3)	4	1	50	1	15	--	--	--	--	--	--
Total	75,000	2,080,000	11,000	320,000	1,420	38,100	856	1,740	14,500	34,200	11,600	386,000

-- Zero.

¹Table includes data available through August 17, 2018. Data are rounded to no more than three significant digits; may not add to totals shown.

²Unwrought and other forms.

³Less than 1/2 unit.

Source: U.S. Census Bureau.

TABLE 4
U.S. EXPORTS OF PLATINUM-GROUP METALS, BY COUNTRY OR LOCALITY¹

Country or locality	Palladium			Platinum			Iridium, osmium, ruthenium			Rhodium			Waste and scrap		
	Quantity, Pd content (kilograms)	Value (thousands)	Pt content (kilograms)	Quantity, Pt content (kilograms)	Value (thousands)	Quantity, gross weight (kilograms)	Value (thousands)	Quantity, Rh content (kilograms)	Value (thousands)	Quantity, Pt content (kilograms)	Value (thousands)	Quantity, Pt content (kilograms)	Value (thousands)		
														17,500	\$272,000
2016:															
2017:															
Argentina	1	3	108	3,280	--	--	--	--	--	--	--	--	--	--	
Australia	61	1,700	95	2,570	55	1,070	--	--	--	--	--	--	--	--	
Belarus	27	198	--	--	--	--	--	--	--	--	--	--	--	--	
Belgium	31	757	(2)	3	2	43	18	720	24,000	46,600					
Brazil	392	11,100	48	1,050	--	--	--	--	--	3	84				
Canada	1,990	32,500	183	6,510	2	28	(2)	50	497	4,000					
China	3,990	88,600	163	4,010	64	1,250	323	9,960	--	--					
Colombia	25	439	(2)	8	1	7	--	--	--	--					
Costa Rica	33	391	113	1,730	--	--	--	--	--	--					
Czechia	24	267	35	1,080	1	43	(2)	4	21	514					
Denmark	25	389	(2)	6	--	--	--	--	--	--					
Dominican Republic	--	--	12	164	--	--	--	--	--	--					
Finland	29	99	1	28	--	--	--	--	--	--					
France	270	2,480	36	1,180	12	240	--	--	--	--					
Germany	6,090	98,800	7,490	226,000	15	273	160	6,050	7,370	59,300					
Hong Kong	1,130	26,900	121	2,950	72	822	(2)	54	1	19					
India	132	2,670	385	12,100	52	531	--	--	103	3,310					
Ireland	202	1,660	157	4,500	1	3	--	--	--	--					
Israel	1,250	7,710	7	171	--	--	(2)	17	--	--					
Italy	198	2,980	756	22,900	--	--	50	2,120	15,100	4,990					
Japan	1,080	24,000	921	28,900	530	5,250	101	4,860	121,000	152,000					
Korea, Republic of	759	8,210	322	9,260	2	29	(2)	17	1	25					
Laos	--	--	33	1,040	--	--	--	--	--	--					
Luxembourg	3,300	88,700	1,950	59,600	--	--	16	580	--	--					
Mexico	216	2,950	639	14,100	4	126	(2)	54	--	--					
Netherlands	9	40	2	100	9	239	--	--	--	--					
New Zealand	27	608	2	56	--	--	--	--	--	--					
Peru	14	178	(2)	11	--	--	--	--	--	--					
Saudi Arabia	26	339	--	--	--	--	--	--	--	--					
Singapore	19	394	2,010	60,600	--	--	30	987	2	45					
Slovakia	--	--	32	850	--	--	--	--	--	--					
South Africa	1	8	--	--	--	--	141	4,890	1,390	39,200					
Spain	11	141	(2)	3	--	--	--	--	--	--					
Switzerland	28,700	426,000	277	8,910	4	122	--	--	5,150	89,600					
Taiwan	1,870	48,400	92	2,560	50	479	--	--	--	--					
Thailand	140	3,670	47	1,320	--	--	1	48	--	--					
Turkey	19	138	13	168	1	6	(2)	14	--	--					
United Arab Emirates	3	46	1	36	23	545	(2)	6	--	--					
United Kingdom	222	4,340	576	15,200	32	577	3	236	19,600	279,000					
Vietnam	6	37	20	625	--	--	--	--	--	--					

See footnotes at end of table.

TABLE 4—Continued
 U.S. EXPORTS OF PLATINUM-GROUP METALS, BY COUNTRY OR LOCALITY¹

Country or locality	Palladium		Platinum		Iridium, osmium, ruthenium		Rhodium		Waste and scrap	
	Quantity, Pd content (kilograms)	Value (thousands)	Quantity, Pt content (kilograms)	Value (thousands)	Quantity, gross weight (kilograms)	Value (thousands)	Quantity, Rh content (kilograms)	Value (thousands)	Quantity, Pt content (kilograms)	Value (thousands)
2017:—Continued										
Other	35	\$519	18	\$501	6	\$38	(2)	\$12	1	\$28
Total	52,300	888,000	16,700	494,000	939	11,700	844	30,700	195,000	679,000

-- Zero.

¹Table includes data available through August 17, 2018. Data 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.

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

(Kilograms)

Country or locality ³	2013	2014	2015	2016	2017
Palladium:					
Australia ^{e,4}	610 ^r	600	420 ^r	590	600
Botswana	1,742	1,120	930 ^{r,e}	-- ^e	-- ^e
Canada ^e	16,000 ^r	19,000 ^r	20,000 ^r	19,000 ^r	17,000
China	850	850	1,200	1,300	1,400
Finland	766 ^r	808 ^r	784 ^r	901 ^r	1,021
Japan ⁵	6,239	6,969	7,073	7,172	7,715
Poland ^{e,6}	65 ^r	51	58 ^r	58 ^r	58
Russia	80,247 ^r	82,735 ^r	81,056 ^r	79,438 ^r	85,161
Serbia	25	23	31	31 ^r	38
South Africa	76,008	58,410	82,691	76,273	86,817
United States ⁷	12,600	12,400	12,500	13,100	13,600 ^e
Zimbabwe	10,153 ^r	10,138 ^r	10,055 ^r	12,222 ^r	12,000 ^e
Total	205,000 ^r	193,000	217,000 ^r	210,000 ^r	226,000
Platinum:					
Australia ^{e,4}	170	170	120 ^r	170 ^r	170
Botswana	280	249 ^r	190 ^{r,e}	-- ^e	-- ^e
Canada ^e	8,900	11,000	12,000 ^r	11,000 ^r	9,500
China	1,600	1,600	2,300	3,000	2,500
Colombia	1,520 ^r	1,142 ^r	861	917 ^r	566
Ethiopia ^e	--	--	5	5	5
Finland	946	1,060	992 ^r	1,178 ^r	1,418
Japan ⁵	1,273 ^r	1,124 ^r	1,379 ^r	1,485 ^r	1,747
Poland ^{e,6}	111 ^r	86	99 ^r	98 ^r	97
Russia	23,000 ^{r,e}	23,000 ^{r,e}	22,182 ^r	20,872 ^r	21,802
Serbia	2	3	4	4	2
South Africa	137,024	93,991	139,125	133,241	143,232
United States ⁷	3,720	3,660	3,670	3,890	3,980 ^e
Zimbabwe	13,066 ^r	12,483 ^r	12,564 ^r	15,110 ^r	14,000 ^e
Total	192,000 ^r	150,000	195,000	191,000	199,000
Other platinum-group metals:					
Canada ^e	890 ^r	1,100	1,200	1,100 ^r	950
Russia ^e	7,400 ^r	8,200	7,600	7,700 ^r	6,100
South Africa	51,156	36,043	53,699	54,139	53,816
Zimbabwe	2,678	2,667	2,612	3,094 ^r	3,000 ^e
Total	62,100 ^r	48,000	65,100	66,000 ^r	63,900
Grand total	459,000 ^r	391,000 ^r	477,000 ^r	467,000 ^r	489,000

^eEstimated. ^rRevised. -- Zero.

¹Table includes data available through July 10, 2018. 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.

²Platinum-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 and (or) localities listed, Indonesia and the Philippines may have produced limited quantities of PGMs, but available information was inadequate to make reliable estimates of output. A part of this output is, however, presumably included in this table and credited to Japan.

⁴PGM recovered from nickel ore that was processed domestically. PGMs 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 the average platinum and palladium content from electrolytic copper refining.

⁷Byproduct platinum and palladium produced from gold-copper and nickel ores were excluded.

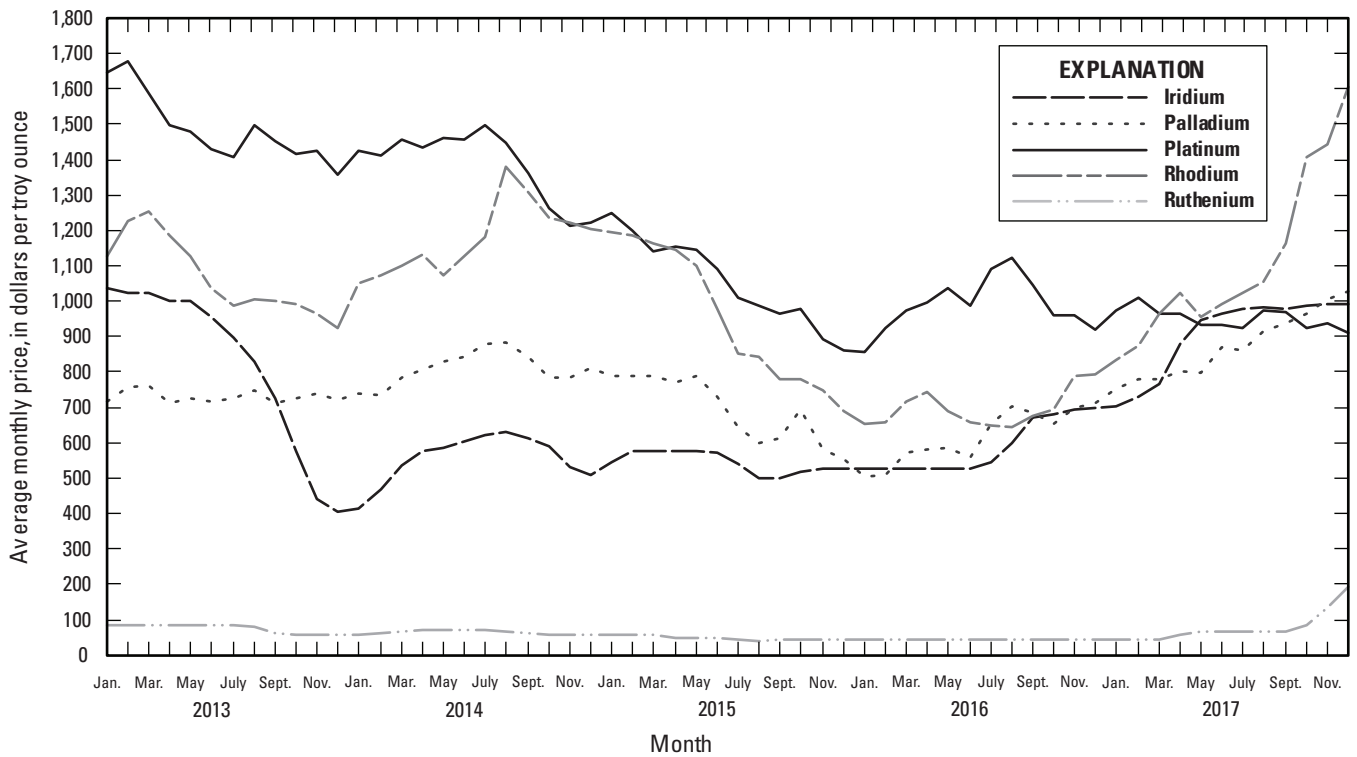


Figure 1. Engelhard unfabricated average monthly prices for the platinum-group metals (iridium, palladium, platinum, rhodium, and ruthenium) from 2013 through 2017. Source: Platts Metals Week.