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PLATINUM-GROUP METALS [ADVANCE RELEASE]

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Platinum-Group Metals

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The platinum-group metals (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.

In 2019, the United States was the world's fourth-leading producer of palladium and the fifth-leading producer of platinum (table 5). Sibanye-Stillwater Ltd. (South Africa), the only domestic mine producer of non-byproduct PGMs, recovered PGMs from its Stillwater and Boulder Mines in Montana. Domestic production of palladium and platinum was 14,300 kilograms (kg) and 4,150 kg, respectively, each essentially unchanged from that in 2018 (table 1). Recycling was a significant source of PGMs as well, accounting for about 30% of the total global supply of palladium, platinum, and rhodium in 2019 (Cowley, 2020, p. 29, 32, 38).

In 2019, the automobile industry continued to be the leading consumer of PGMs. Catalytic converters accounted for approximately 88% of global primary rhodium consumption, 84% of primary palladium consumption, and 34% of primary platinum consumption (Cowley, 2020, p. 29, 32, 38). The annual average prices for ruthenium, iridium, palladium, and rhodium increased by 7%, 15%, 49%, and 76%, respectively, compared with those in 2018; the platinum price decreased slightly (fig. 1, table 1). In 2019, excluding waste and scrap, imports of PGMs decreased by 17% and exports decreased slightly. Note that exports of iridium, osmium, and ruthenium are combined and reported in gross weight because they were not reported separately when exported (table 1). World mine production of PGMs totaled 475,000 kg, slightly more than the total in 2018. Most of the world's mine supply of PGMs was produced in South Africa and Russia, which accounted for 56% and 27%, respectively, of global mined PGM production (table 5).

Legislation and Government Programs

The Defense Logistics Agency Strategic Materials, U.S. Department of Defense, announced the potential disposal of PGM materials under its fiscal year 2019 (October 1, 2018, through September 30, 2019) Annual Materials Plan (AMP). Maximum disposal limits in the fiscal year 2019 AMP for PGM materials were set at 261 kg of platinum and 15 kg of iridium (Defense Logistics Agency Strategic Materials, 2018). At the calendar 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.

Effective May 10, 2019, the Office of the U.S. Trade Representative (USTR) modified the 2018 tariff rate of 10% on certain products imported from China to 25%, which was implemented under section 301(b) of the Trade Act of 1974 (Office of the U.S. Trade Representative, 2019b). PGM-containing materials affected by the tariffs were outlined in Annex A of the initial September 2018 action and included the following Harmonized Tariff Schedule of the United States (HTS) codes: 7110.11.00, 7110.19.00, and 7115.10.00 (platinum); 7110.21.00 and 7110.29.00 (palladium); 7110.31.00 and 7110.39.00 (rhodium); 7110.41.00 and 7110.49.00 (iridium, osmium, and ruthenium); and 7112.92.00 (platinum waste and scrap) (Office of the U.S. Trade Representative, 2018).

The USTR proposed additional import duties on certain products from the European Union in April in response to a section 301 investigation into European Union subsidies on large civil aircraft (Office of the U.S. Trade Representative, 2019a). PGM-containing materials on the preliminary list of products subject to the additional import tariffs included HTS code 7110.21.00 (palladium, unwrought or in powder form). In October, the USTR imposed additional import tariffs of 10% to 25% on certain items from the European Union (84 FR 54250) but palladium was not included in the list of items.

Production

Mine.—During 2019, U.S. palladium and platinum mine production was 14,300 kg and 4,150 kg, respectively. Compared with 2018, palladium and platinum production were essentially unchanged for each (table 1).

Sibanye-Stillwater Ltd. produced PGMs from two mines in the United States, the Stillwater Mine and the East Boulder Mine, both located in Montana. In 2019, the Stillwater Mine produced 11,700 kg of PGMs, and the East Boulder Mine produced 6,770 kg of PGMs. Sibanye-Stillwater Ltd. processed 1.41 million metric tons (Mt) of ore from the mines with a combined mill-head grade of 14 grams per metric ton PGMs and a PGM mill recovery rate of 92% (Sibanye-Stillwater Ltd., 2020b, p. 129–130). The concentrates from the mines were smelted and then processed at the base-metals refinery at Sibanye-Stillwater Ltd.'s metallurgical complex in Columbus, MT, producing a PGM-rich filter cake. Final refining of PGMs to commerical grade was done by Johnson Matthey Plc (United Kingdom) in a facility in the United Kingdom.

At yearend 2019, Sibanye-Stillwater Ltd. reported proven and probable reserves at its Montana mines of 48.3 Mt of ore with a palladium-to-platinum ratio ranging from 3.4:1 to 3.6:1 and about 836,000 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. Production continued from the Blitz development project, a mine expansion project adjacent to the Stillwater Mine, producing about 2,300 kilograms per year (kg/yr) of PGMs and contributing about 50,000 kg to the mineral reserve estimate, a 5% increase from the mineral reserve amount in 2018 (Sibanye-Stillwater Ltd., 2020c, p. 2, 21, 25, 29). Full production from the Blitz project was expected to be completed

by 2022, with a capacity of about 9,300 kg/yr of PGMs (Sibanye-Stillwater Ltd., 2020b, p. 32).

Sibanye-Stillwater Ltd. also reported that the expansion project at the East Boulder Mine, known as Fill the Mill, was on track to finish by 2021. The project would add approximately 1,200 kg/yr of PGM production at the East Boulder Mine. The expansion projects, once completed, would yield an estimated sustainable mine production of 26,000 kg/yr of PGMs (Sibanye-Stillwater Ltd., 2020b, p. 32).

In 2019, two PGM exploration projects in the Duluth Complex of Minnesota continued to progress towards development. Twin Metals Minnesota LLC (Twin Metals) (St. Paul, MN), a subsidiary of Antofagasta PLC (United Kingdom), submitted a Mine Plan of Operations to the Bureau of Land Management and a Scoping Environmental Assessment Worksheet Data Submittal to the Minnesota Department of Natural Resources. In doing so, Twin Metals began a multiyear scoping and environmental review process for the construction of an underground cobalt, copper, nickel, and PGM mine in Minnesota (Twin Metals Minnesota LLC, 2019). The Twin Metals project included three deposits in close proximity—the Birch Lake, Maturi, and Spruce Road deposits.

In March, PolyMet Mining, Inc. (PolyMet) (Canada) announced that it had received a wetlands permit from the United States Army Corp of Engineers (USACE) for its NorthMet copper-nickel-PGM project in the Duluth Complex. The wetlands permit was the last permit required to construct and operate the NorthMet project. Legal challenges were filed in the Minnesota Federal court against USACE's wetlands permit in September, although PolyMet was not named as a defendant in the cases. However, PolyMet took steps to mitigate the challenges (PolyMet Mining, 2020, p. 4).

Additional lawsuits were filed in the Minnesota Court of Appeals challenging (1) aspects of the water quality permit issued to PolyMet by the Minnesota Department of Natural Resources in November 2018; (2) the water quality and air emission quality permits issued by the Minnesota Pollution Control Agency; (3) and the section 401 certification issued in December 2018. The water quality permit litigation was moved to the Ramsey County Court District in June 2019 for an evidentiary hearing (PolyMet Mining, 2020, p. 4).

Refinery.—The U.S. Geological Survey surveyed domestic precious-metals refinery producers on an annual basis. Of the 20 companies that were surveyed for commercial-grade PGM refinery production for 2019, 9 companies responded. The amount of refinery production by the companies that did not respond to the survey was estimated based on prior reports or on information from other sources; however, it was still likely underestimated.

Using these data, U.S. palladium and platinum refinery production during 2019 was 44,700 kg and 27,200 kg, respectively. Compared with 2018, this represented increases of 9% for palladium and 10% for platinum (table 1).

Following a petition to file for Chapter 11 bankruptcy protection in November 2018, Republic Metals Corp., based in Florida, auctioned off its assets in 2019. Asahi Holdings, Inc. (Japan) won the auction for $25.5 million (Weaver and Nehamas, 2019). Asahi Refining Florida was established as the new operation under the company Asahi Refining, the North American subsidiary of Asahi Holdings, Inc.

Recycling.—In 2019, PGMs were recycled from three main sources—catalytic converters, electronics, and jewelry. Globally, more than 185,000 kg of secondary PGMs was recovered, accounting for approximately 30% of the global supply of secondary PGMs. Recycled catalytic converters were the predominant source of secondary PGMs (Cowley, 2020, p. 24, 28, 32). An estimated 53,000 kg of PGMs was hypothetically available for recovery from catalytic converters in the United States, which was about 48% of the world total (CPM Group, 2019, p. 32–33, 119, 180).

Sibanye-Stillwater Ltd. reported that it recovered 26,500 kg of PGMs from spent catalytic converters and other industrial sources in 2019. Of the total recycled, Sibanye-Stillwater Ltd. toll-refined 3,940 kg of PGMs. In 2019, Sibanye-Stillwater Ltd. sold 23,300 kg of secondary PGMs (Sibanye-Stillwater Ltd., 2020b, p. 129).

Consumption

The PGMs are consumed in several different industries in the United States and are often used together in the same applications. Owing to similar atomic structures and chemistries, individual PGMs 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.

PGMs are used in electronics including 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. Because of biocompatibility and nonreactivity of the metals with organic tissue, PGMs are used in dental and medical devices as well as in jewelry. Resistance to chemical corrosion and oxidation and relative rarity make PGMs appealing for making jewelry as well as physical investment in the form of coin and bullion.

Palladium.—In 2019, apparent domestic palladium consumption, defined as primary mine production plus secondary production plus imports minus exports, excluding imports and exports of waste and scrap, was 95,900 kg, essentially unchanged from that in 2018. Catalytic converter production was the leading end use for palladium, accounting for 71% of consumption in North America. Other uses, including chemical and petroleum catalysts, electronics, dental applications, and jewelry, accounted for the remaining 29% (CPM Group, 2019, p. 123).

Platinum.—In 2019, apparent domestic platinum consumption, defined as mine production plus recycling plus imports minus exports, was 39,100 kg, a decrease of 26% compared with apparent consumption in 2018. The leading end uses for platinum in 2019 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 2019, adequate data were not available to determine the apparent consumption of iridium, osmium, rhodium, or ruthenium.

Prices

According to Platts Metals Week, in 2019, the Engelhard unfabricated annual average prices for ruthenium, iridium, palladium, and rhodium increased by 7%, 15%, 49%, and 76%, respectively. The annual average price for platinum decreased slightly compared with the annual average price in 2018 (table 1). Figure 1 illustrates the average monthly prices from January 2015 to December 2019.

Iridium.—The annual average iridium price in 2019 was $1,485.80 per troy ounce, which was 15% greater than that in 2018. The iridium price began the year at $1,485 per troy ounce and ended the year at $1,490 per troy ounce. The average annual iridium price increase in 2019 was primarily attributed to an increased use of iridium crucibles to produce lithium-tantalite crystals, which are required components in smartphones (Heraeus Precious Metals GmbH & Co. KG, 2020, p. 10).

Palladium.—The annual average palladium price in 2019 was $1,544.31 per troy ounce, which was 49% greater than that in 2018. The palladium price began 2019 at $1,273 per troy ounce and fluctuated throughout the year with a general upward trend, ending the year at $1,940 per troy ounce.

Platinum.—In 2019, the annual average platinum price was $866.94 per troy ounce, which was slightly less than the annual average price in 2018. The spot-market price of platinum began the year at $788 per troy ounce and fluctuated throughout the year, ending the year at $985 per troy ounce.

Rhodium.—The annual average rhodium price in 2019 was $3,918.78 per troy ounce, which was 76% greater than that in 2018. The rhodium spot-market price began the year at $2,460 per troy ounce and generally trended upward until August when prices began to rise sharply, ending the year at $6,050 per troy ounce. The price reached a record high of $6,150 in December. The price increase for rhodium in 2019 was attributed to limited availability of refined rhodium and increased demand for rhodium in the automotive sector to achieve higher fuel efficiency standards (Heraeus Precious Metals GmbH & Co. KG, 2020, p. 8).

Ruthenium.—The annual average ruthenium price in 2019 was $262.59 per troy ounce, which was 7% greater than that in 2018. The ruthenium spot-market price began the year at $275 per troy ounce and decreased gradually to $255 per troy ounce by yearend. The overall decrease in the ruthenium spot-market price in 2019 was largely owing to the introduction of alternate technologies in the manufacture of hard-disk drives and heat-assisted magnetic recording technology that do not require ruthenium (Heraeus Precious Metals GmbH & Co. KG, 2020, p. 9).

Foreign Trade

In 2019, imports for consumption of palladium, excluding waste and scrap, decreased by 9% to 84,300 kg, from 92,900 kg in 2018. The imports were sourced predominantly from Russia (35%), South Africa (33%), Canada (8%), and Italy (6%). In 2019, imports for consumption of platinum, excluding waste and scrap, decreased by 28% to 42,300 kg, from 58,500 kg in 2018. The leading sources of platinum imports were South Africa (29%), Germany (24%), Italy (10%), and Switzerland (9%). Imports for consumption of rhodium increased by 4% compared with imports in 2018. Combined imports of iridium, osmium, and ruthenium decreased by 36% to 12,000 kg. Leading import sources for iridium, osmium, rhodium, and ruthenium in 2019 were South Africa (44%), Germany, (20%), the United Kingdom (19%), and Belgium (7%) (tables 2, 3).

In 2019, exports of palladium, excluding waste and scrap, totaled 55,500 kg, a 5% increase from exports in 2018. Exports of platinum, excluding and waste and scrap, totaled 17,400 kg, a decrease of 8% compared with exports in 2018. Exports of rhodium and combined exports of iridium, osmium, and ruthenium decreased by 40% and 47%, respectively, compared with exports in 2018 (tables 1, 4).

World Review

In 2019, world mine production of PGMs increased slightly to 475,000 kg from 470,000 kg (revised) in 2018 (table 5). South Africa accounted for the largest share of total PGM mine production, accounting for 56% of global production, followed by Russia, 27%; Canada and Zimbabwe, 6% each; the United States, 4%; and other countries, less than 2%. In 2019, world platinum mine production decreased slightly to 186,000 kg. South Africa accounted for 71% of world platinum production; Russia, 13%; Zimbabwe, 7%; Canada, 4%; the United States, 2%, and other countries, 2%. Global mine production of palladium in 2019 increased by 3% to 227,000 kg. Russia and South Africa accounted for 43% and 36%, respectively, of world palladium production in 2019; Canada, 9%; the United States, 6%; Zimbabwe, 5%; and other countries, 1%. World mine production of other PGMs (iridium, rhodium, and ruthenium) increased by 3% in 2019 compared with that in 2018, and South Africa accounted for 88% of global production.

Belgium.—Umicore N.V., a multinational materials technology company, completed its multiyear expansion project

at its precious-metals refining operations in Hoboken, NJ, which recovered PGMs and other precious metals from electronic and industrial scrap (Umicore N.V., 2020, p. 8, 32). The project increased recycling capacity from 350,000 metric tons per year (t/yr) to 500,000 t/yr. Umicore N.V. planned to use the increased capacity to help meet increasing demand in the global precious-metals market (Umicore N.V., undated).

Brazil.—ValOre Metals Corp. (Canada) entered into a purchase agreement with Jangada Mines Plc (United Kingdom) to acquire 100% interest in the Pedra Branca Project, which is located in a PGM district in Brazil that covers 38,940 hectares (96,223 acres) (ValOre Metals Corp., 2019). The transaction was subject to shareholder and regulatory approvals as well as completion of financial transactions.

Canada.—In December, North American Palladium Ltd. announced it had been acquired by Impala Platinum Holdings Ltd. (Implats) (South Africa) and would continue to operate as a subsidiary under the new name Impala Canada Ltd. (North American Palladium Ltd., 2019b). Prior to the acquisition, North American Palladium Ltd. had become 51% vested in the Sunday Lake Project, with Implats and Transition Metals Corp. as the other vested partners (North American Palladium Ltd., 2019a). The Sunday Lake Project, established in 2016, is a copper-nickel-PGM deposit located within the lower section of the Sunday Lake mafic-ultramafic intrusion in Ontario (Transition Metals Corp., 2016; North American Palladium Ltd., 2019c).

Platinum Group Metals Ltd. announced a new joint venture, Lion Battery Technologies Inc., with Anglo American Platinum Ltd. (South Africa) in July 2019. The joint venture entered into an agreement with Florida International University in Miami, FL, to advance research using platinum and palladium to enhance discharge capacity and cyclability in lithium-air and lithium-sulfur batteries (Platinum Group Metals Ltd., 2019).

In June, Sibanye-Stillwater Ltd. announced an acquisition agreement with Generation Mining Ltd. to form an unincorporated joint venture with Stillwater Canada Inc. The agreement was established to further develop a PGM-copper Marathon deposit in northern Ontario (Sibanye-Stillwater Ltd., 2019c). The acquisition was completed in July and Generation Mining Ltd. filed an independent technical report in accordance with National Instrument 43–101, Standards of Disclosure for Mineral Projects (NI 43–101), in October (Generation Mining Ltd., 2019a, b).

India.—On February 18, Ravindra-Heraeus, a subsidiary of Heraeus Precious Metals GmbH & Co. KG (Germany), established a pyrometallurgical smelter, referred to as the Plasma Metal Recovery System, in India. The new operation included the capacity to process approximately 1,500 t/yr of autocatalysts and other PGM-bearing materials (Heraeus Precious Metals GmbH & Co. KG, 2019).

Russia.—In 2019, PJCS MMC Norilsk Nickel (Nornickel), a leading PGM producer in Russia, produced palladium and platinum from two assets in Russia—JSC Kolskaya Mining and Metallurgical Company (Kola MMC) on the Kola Peninsula and the Polar Division and Medvezhy Ruchey, a wholly owned subsidiary of Nornickel, on the Taymyr Peninsula. Kola MMC made up 62% of Nornickel's total finished PGM production in 2019 (PJCS MMC Norilsk Nickel, 2020, p. 76, 80). Kola MMC produced about 56,800 kg of palladium and 13,700 kg of platinum in 2019, increases of 8% and 15%, respectively, from production in 2018. Nornickel attributed the increases in output to drawdowns from inventory (PJCS MMC Norilsk Nickel, 2020, p. 82).

PGM-containing ore from the Polar Division was concentrated at the Talnakh Concentrator, which underwent preparatory work in 2019 for Stage 3 upgrades (PJCS MMC Norilsk Nickel, 2020, p. 37). Plans for Stage 3 upgrades included new concentration technology, which would increase throughput ore-processing capacity from 10 million metric tons per year (Mt/yr) to 18 Mt/yr. Stage 1 and Stage 2 upgrades were completed in 2015 and 2018, respectively.

Nornickel transferred some of the Polar Division's assets to Medvezhy Ruchy to help finance a brownfield expansion project in the northern part of the Norilsk-1 copper-nickel-PGM deposit, which is in the Norilsk Industrial District (PJCS MMC Norilsk Nickel, 2020, p. 66). PGM production in the Polar Division and Medvezhy Ruchy were about 32,000 kg of palladium and 7,800 kg of platinum, an increase of 5% and a decrease of 3%, respectively, compared with palladium and platinum production in 2018 (PJCS MMC Norilsk Nickel, 2020, p. 79).

Russian Platinum Ltd. planned to invest $15 billion to develop PGM resources in the Taymyr Peninsula as part of a joint venture, known as Arctic Palladium, with MMC Norilsk Nickel PJSC. Russian Platinum Ltd. acquired licenses to mine the Chernogorskoye field and the southern part of Norilsk-1 field in 2011 and 2013, respectively. The company planned to develop an open pit mine as well as construct a concentrator and smelter nearby for processing. The two fields also contain copper and nickel resources (Staalesen, 2019).

South Africa.—Following a court appeal by the Association of Mineworkers and Construction Union and subsequent dismissal by the Competition Appeal Court of South Africa, Sibanye-Stillwater Ltd. announced the acquisition of Lonmin plc (United Kingdom) in June, making the merged company the leading global platinum producer and the second-leading palladium producer (Sibanye-Stillwater Ltd., 2019a, b). The approval of the merger by the South African Competition Tribunal was subject to the condition that the merged company would not dismiss employees at Lonmin plc operations for a period of 6 months following completion of the merger (Sibanye-Stillwater Ltd., 2018).

In August 2019, Jubilee Metals Group Plc (United Kingdom) reported that the grinding and primary recovery circuits were commissioned at the Windsor PGM project, a joint-venture PGM recovery plant in South Africa between Jubilee Metals Group and Northam Platinum Ltd. (Jubilee Metals Group Plc, 2019a, undated). Jubilee used low-grade PGM material for processing in July prior to commissioning, but by the end of August the plant was processing higher grade PGM ore (Jubilee Metals Plc, 2019b). The processed concentrate was sold to a third-party refinery.

Anglo American Platinum Ltd., through its subsidiary Rustenberg Platinum Mines Ltd., acquired prospecting rights from Atlatsa Resources Corp. for the Kwanda North and Central Block in the Northern Limb of the Bushveld Complex. These rights were incorporated into the mining rights at Mogalakwena, a PGM mine near the town of Mokopane (Anglo American Platinum Ltd., 2019; 2020, p. 6–7).

United Kingdom.—Metallix Refining Inc. (United States) opened a new refining operation, Metallix Refining Europe Ltd., in South Yorkshire, England. The United Kingdom location would handle metal scrap recycling and refining processes and serve markets in Europe (Metallix Refining Inc., 2019).

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.—On January 15, the African Export-Import Bank (Afeximbank) and Great Dyke Investments (Pvt) Ltd., a 50–50 joint venture between Vi Holding (Russia) and Landela Mining Venture (Pvt) Ltd., signed a memorandum of understanding, which stated that Afreximbank could potentially finance up to $192 million for developing Great Dyke Investments' Darwendale platinum deposit in Zimbabwe. Full production capacity of the mine and associated recovery plant was estimated at 26,700 kg/yr of PGMs (Russia & CIS Metals and Mining Weekly, 2019). Great Dyke Investments also announced that financial negotiations were in progress to develop the first phase of the Darwendale integrated PGM mining, processing, and smelting project in Zimbabwe. The intergovernmental agreement was signed by the Governments of Russia and Zimbabwe and a special mining lease was granted for the project (Vi Holding, undated). The agreement was expected to be completed in late March 2020, with production projected to start in 2021, and the first concentrate expected to be produced in 2022. Construction began in 2019 (Dzirutwe, 2019; Great Dyke Investments (Pvt) Ltd., 2019, undated; Kadzere, 2019).

On March 7, the Government of Zimbabwe announced that it would remove the restriction under the Indigenization and Economic Empowerment Act that limited platinum operations in the country to 49% foreign ownership, which would allow foreign investment in mining projects (Thomson Reuters Corp., 2019).

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.

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TABLE 1
SALIENT PLATINUM-GROUP METALS STATISTICS[1]

		2015	2016	2017	2018	2019
United States:						
Mine production:[2]						
Palladium, Pd content:						
Quantity	kilograms	12,500	13,100	14,000 e	14,300	14,300
Value	thousands	$280,000	$259,000	$380,000 e	$475,000 r	$711,000
Platinum, Pt content:						
Quantity	kilograms	3,670	3,890	4,000 e	4,160	4,150
Value	thousands	$125,000	$124,000	$120,000 e	$118,000	$116,000
Refinery production:[3]						
Palladium, Pd content:						
Quantity	kilograms	38,300	43,800	38,000	40,900 r	44,700
Value	thousands	$857,000	$870,000	$1,070,000	$1,360,000	$2,220,000
Platinum, Pt content:						
Quantity	kilograms	26,800	26,100	27,800	24,800	27,200
Value	thousands	$911,000	$832,000	$850,000	$704,000	$758,000
Imports for consumption, refined:						
Iridium, Ir content	kilograms	1,010	1,300	1,420	1,020	875
Osmium, Os content	do.	8	27	856	25	(4)
Palladium, Pd content	do.	85,300	80,400	86,000	92,900	84,300
Platinum, includes coins, Pt content	do.	42,700	42,300	53,200	58,500	42,300
Rhodium, Rh content	do.	10,600	10,700	11,600	14,500	15,000
Ruthenium, Ru content	do.	8,230	8,410	14,600	17,900	11,200
Waste and scrap, Pt content	do.	123,000	154,000	354,000	40,700	54,300
Exports, refined:	do.					
Iridium, osmium, and ruthenium, gross weight	do.	781	736	939	2,500 r	1,330
Palladium, Pd content	do.	23,000	17,500	52,300	52,900 r	55,500
Platinum, Pt content	do.	14,400	14,000	16,700	18,900	17,400
Rhodium, Rh content	do.	759	794	844	2,010	1,210
Waste and scrap, Pt content	do.	246,000	48,100	37,200 r	31,700 r	20,800
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:[5]						
Iridium	dollars per troy ounce	694.99 r	586.90	908.35	1,293.27	1,485.80
Palladium	do.	544.19 r	617.39	874.30	1,036.43	1,544.31
Platinum	do.	954.90 r	989.52	951.23	882.66	866.94
Rhodium	do.	1,056.09 r	696.84	1,112.59	2,225.30	3,918.78
Ruthenium	do.	47.63	42.00	76.86	244.41	262.59
Employment		1,440	1,430	1,510	1,630	1,790
World, mine production, platinum-group-metal content	kilograms	470,000	460,000	456,000	470,000 r	475,000

eEstimated. rRevised. do. Ditto.

[1]Table includes data available through June 16, 2020. Data are rounded to no more than three significant digits, except prices.

[2]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.

[3]Data revised based on new sources of information and publicly available reports. Iridium, rhodium, and ruthenium were recovered, but data were withheld to avoid disclosing proprietary information.

[4]Less than ½ unit.

[5]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[1]

Country or locality	Grain 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)
2018	1,050 r	$28,200 r	43,100	$1,250,000	3,370	$110,000	9,780	$304,000 r	1,160	$34,900
2019:										
Australia	--	--	--	--	--	--	(2)	12	349	10,100
Austria	--	--	--	--	--	--	121	3,990	50	1,450
Belgium	--	--	2,320	63,400	--	--	--	--	--	--
Canada	187	5,420	--	--	--	--	407	11,900	729	21,700
China	--	--	--	--	--	--	(2)	12	11	366
Colombia	25	552	--	--	166	5,110	5	110	--	--
Costa Rica	--	--	--	--	3	92	257	7,460	--	--
Czechia	--	--	--	--	--	--	6	235	--	--
Dominican Republic	--	--	--	--	1	35	1	30	--	--
France	(2)	10	56	1,540	--	--	189	4,750	--	--
Germany	3	94	4,420	124,000	1,020	31,600	4,700	168,000	79	3,350
Ireland	--	--	--	--	1	80	1	13	--	--
Italy	--	--	4,120	119,000	(2)	10	6	162	--	--
Japan	(2)	9	145	3,840	390	15,200	33	821	--	--
Korea, Republic of	--	--	409	10,800	--	--	(2)	4	--	--
Norway	--	--	998	27,400	30	963	21	349	--	--
Russia	--	--	457	14,200	--	--	--	--	(2)	13
Singapore	129	5,990	--	--	1,740	100,000	210	6,980	--	--
South Africa	--	--	12,000	327,000	81	2,630	118	3,630	4	198
Switzerland	--	--	456	12,700	447	12,400	3,040	85,400	24	931
Taiwan	--	--	--	--	--	--	921	10,500	--	--
United Kingdom	15	611	761	21,900	2	122	532	15,600	77	2,540
Other	--	--	--	--	2	76	6	159	(2)	15
Total	360	12,700	26,200	726,000	3,880	168,000	10,600	320,000	1,320	40,600

rRevised. -- Zero.
[1]Table includes data available through June 8, 2020. Data are rounded to no more than three significant digits; may not add to totals shown.
[2]Less than ½ unit.

Source: U.S. Census Bureau.

TABLE 3

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

	Palladium[2]		Iridium[2]		Osmium[2]		Ruthenium[2]		Rhodium[2]		Waste and scrap	
Country or locality	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)
2018	92,900	$3,110,000	1,020	$38,000	25	$136	17,900	$133,000	14,500	$987,000	40,700	$1,060,000
2019:												
Australia	--	--	--	--	--	--	--	--	--	--	996	30,300
Austria	210	8,690	--	--	--	--	--	--	--	--	3	108
Belgium	2,890	144,000	--	--	--	--	622	5,380	1,340	146,000	264	13,600
Brazil	--	--	--	--	--	--	--	--	--	--	1,130	25,800
Canada	6,950	304,000	--	--	--	--	--	--	10	378	5,670	166,000
Chile			--	--	--	--	--	--	--	--	419	10,400
China	1	17	(3)	4	--	--	--	--	(3)	2	277	34,000
Colombia	--	--	--	--	--	--	--	--	--	--	113	2,470
France	1	41	--	--	--	--	--	--	--	--	438	10,800
Germany	3,460	170,000	98	4,540	(3)	2	2,500	21,800	2,820	365,000	5,890	157,000
India	118	6,840	--	--	--	--	--	--	--	--	87	2,180
Italy	5,280	209,000	4	161	--	--	165	1,430	875	63,100	1,120	36,900
Japan	1,570	53,300	96	3,670	--	--	45	318	44	4,220	4,390	136,000
Jordan	--	--	--	--	--	--	--	--	--	--	109	3,280
Korea, Republic of	320	15,000	2	80	--	--	--	--	5	504	101	3,080
Kuwait	--	--	--	--	--	--	--	--	--	--	923	26,300
Malaysia	--	--	--	--	--	--	--	--	--	--	328	7,630
Mexico	10	103	--	--	--	--	--	--	--	--	3,900	110,000
Norway	1,360	65,300	--	--	--	--	--	--	36	4,740	7	309
Poland	(3)	5	--	--	--	--	--	--	--	--	245	9,090
Russia	29,300	1,450,000	13	379	--	--	48	414	1,140	126,000	--	--
Saudi Arabia	--	--	--	--	--	--	--	--	--	--	1,150	30,500
Singapore	--	--	--	--	--	--	--	--	8	509	2,190	77,700
South Africa	28,000	1,150,000	383	17,400	--	--	5,140	40,400	6,390	704,000	127	6,350
Switzerland	2,320	110,000	--	--	--	--	--	--	3	223	2	48
Taiwan	106	4,500	--	--	--	--	--	--	(3)	17	1,020	38,200
Thailand	--	--	--	--	--	--	--	--	--	--	334	16,000
Trinidad and Tobago	--	--	--	--	--	--	--	--	--	--	145	4,040
United Arab Emirates	--	--	--	--	--	--	--	--	--	--	324	8,610
United Kingdom	2,350	75,100	278	12,000	--	--	2,580	21,300	2,360	249,000	21,700	97,500
Other	23	1,080	1	40	--	--	60	493	--	--	886	33,300
Total	84,300	3,770,000	875	38,300	(3)	2	11,200	91,600	15,000	1,660,000	54,300	1,100,000

-- Zero.

[1]Table includes data available through June 8, 2020. Data are rounded to no more than three significant digits; may not add to totals shown.

[2]Unwrought and other forms.

[3]Less than ½ unit.

Source: U.S. Census Bureau.

TABLE 4

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

	Palladium		Platinum		Iridium, osmium, ruthenium		Rhodium		Waste and scrap	
Country or locality	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)
2018	52,900 r	$1,060,000	18,900	$587,000	2,500 r	$42,600	2,010	$130,000	31,700 r	$613,000 r
2019:										
Argentina	--	--	45	1,560	--	--	--	--	--	--
Australia	124	1,950	131	4,310	96	1,950	26	1,060	--	--
Belarus	45	615	--	--	--	--	--	--	--	--
Belgium	409	11,000	298	8,370	--	--	65	4,790	317	11,500
Brazil	473	21,300	336	9,500	--	--	--	--	--	--
Canada	2,550	103,000	223	7,720	(2)	3	1	118	415	12,200
China	1,000	25,900	141	3,480	53	480	27	2,320	--	--
Colombia	19	330	1	24	--	--	--	--	--	--
Costa Rica	45	1,470	538	8,640	6	64	--	--	--	--
Czechia	10	238	--	--	--	--	--	--	--	--
Denmark	20	351	(2)	3	--	--	--	--	--	--
Dominican Republic	2	8	5	186	--	--	(2)	10	--	--
Finland	10	75	1	30	--	--	--	--	--	--
France	346	4,270	183	2,130	74	786	--	--	--	--
Germany	6,780	232,000	6,300	199,000	190	1,950	167	23,500	3,180	116,000
Hong Kong	1,290	39,800	97	3,310	7	68	11	1,690	--	--
Hungary	--	--	9	102	--	--	--	--	--	--
India	150	1,820	433	12,600	21	215	(2)	17	--	--
Ireland	243	3,490	255	7,340	18	598	7	414	--	--
Israel	1,050	9,550	11	271	4	20	--	--	--	--
Italy	3,740	170,000	680	18,500	72	1,850	16	2,120	920	31,600
Japan	1,510	59,200	1,760	50,600	497	7,130	302	39,900	5,490	247,000
Korea, Republic of	1,530	56,700	1,150	40,600	64	304	151	21,200	1	21
Kuwait	8	219	--	--	--	--	--	--	--	--
Laos	--	--	11	316	--	--	--	--	--	--
Mexico	264	3,750	391	8,550	23	317	1	174	3	80
Netherlands	10	49	4	158	7	173	--	--	--	--
New Zealand	34	812	2	55	--	--	(2)	7	--	--
Norway	8	262	117	3,760	--	--	--	--	--	--
Poland	8	75	1	57	(2)	16	--	--	--	--
Saudi Arabia	13	326	203	1,630	--	--	--	--	--	--
Singapore	93	2,070	70	1,910	--	--	10	1,210	--	--
South Africa	3	19	10	279	--	--	324	44,200	191	8,680
Switzerland	25,400	421,000	1,940	51,500	6	110	--	--	5,080	58,000
Taiwan	724	36,000	171	4,840	123	652	(2)	6	--	--
Thailand	300	4,730	35	992	--	--	(2)	13	--	--
Ukraine	13	22	--	--	--	--	--	--	--	--
United Kingdom	7,190	404,000	1,800	93,200	66	2,440	103	9,030	5,160	239,000
Uruguay	120	129	5	198	(2)	3	--	--	--	--
Vietnam	6	32	26	791	--	--	--	--	--	--
Other	25	272	24	604	7	149	(2)	3	1	33
Total	55,500	1,620,000	17,400	547,000	1,330	19,300	1,210	152,000	20,800	724,000

rRevised. -- Zero.

[1]Table includes data available through June 8, 2020. Data are rounded to no more than three significant digits; may not add to totals shown.

[2]Less than ½ unit.

Source: U.S. Census Bureau.

TABLE 5

PLATINUM-GROUP METALS: WORLD MINE PRODUCTION, BY COUNTRY OR LOCALITY[1, 2]

(Kilograms, platinum-group-metal content)

Country or locality[3]	2015	2016	2017	2018	2019
Palladium:					
Australia[e, 4]	420	590	600	420	380
Botswana	930 [e]	--	--	--	--
Canada[e]	24,000	22,000	19,000	20,000	20,000
China	1,200	1,400	1,400	1,300	1,300 [e]
Finland	784	901	1,021	1,157	699
Russia[e]	85,000	83,000	88,000	90,000	98,000
Serbia	31	31	38	55 [r]	40 [e]
South Africa	82,691	76,273	80,132	80,629	80,684
United States[4]	12,500	13,100	14,000 [e]	14,300	14,300
Zimbabwe	10,055	12,222	11,822	12,094 [r]	11,399
Total	218,000	209,000	216,000	220,000	227,000
Platinum:					
Australia[e, 4]	120	170	170	120	110
Botswana	190 [e]	--	--	--	--
Canada[e]	8,600	8,400	7,600	7,900 [r]	7,800
China	2,300	2,900	2,500	2,500	2,500 [e]
Colombia	861	917	566	269	163
Ethiopia[e]	5	5	4 [r]	4 [r]	2
Finland	992	1,178	1,418	1,576	953
Russia[e]	23,000	22,000	22,000	22,000	24,000
Serbia	4	4	2	5 [r]	4
South Africa	139,125	133,241	131,242	137,053	132,989
United States[4]	3,670	3,890	4,000 [e]	4,160	4,150
Zimbabwe	12,564	15,110	14,257	14,703 [r]	13,546
Total	191,000	188,000	184,000	190,000	186,000
Iridium:					
Canada[e]	100	300	200	200	200
Russia[e]	200	200	300	200	300
South Africa	6,230	6,624	5,973	6,357	6,464
Zimbabwe	507	598	619	586 [r]	833
Total	7,040	7,720	7,090	7,340 [r]	7,800
Rhodium:					
Canada[e]	600	600	60	60 [r]	60
Russia	2,613	2,644	2,115	1,928 [r]	2,426
South Africa	18,722	19,237	18,431	18,608	19,545
Zimbabwe	1,128	1,322	1,283	1,334 [r]	1,199
Total	23,100	23,800	21,900	21,900 [r]	23,200
Ruthenium:					
Canada[e]	300	300	500	500 [r]	500
Russia[e]	1,000	1,000	1,000	1,000	1,300
South Africa	28,747	28,278	24,486	27,999	28,386
Zimbabwe	977	1,174	1,102	1,155 [r]	768
Total	31,000	30,800	27,100	30,700 [r]	31,000
Grand total	470,000	460,000	456,000	470,000 [r]	475,000

[e]Estimated. [r]Revised. -- Zero.

[1]Table includes data available through June 23, 2020. 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.

[2]Platinum-group metal (PGM) mine production only. Does not include refinery production.

[3]In addition to the countries and (or) localities listed, Indonesia and the Philippines may have produced limited quantities of platinum-group metals, but available information was inadequate to make reliable estimates of output.

[4]Byproduct platinum and palladium produced from gold-copper and nickel ores were excluded.

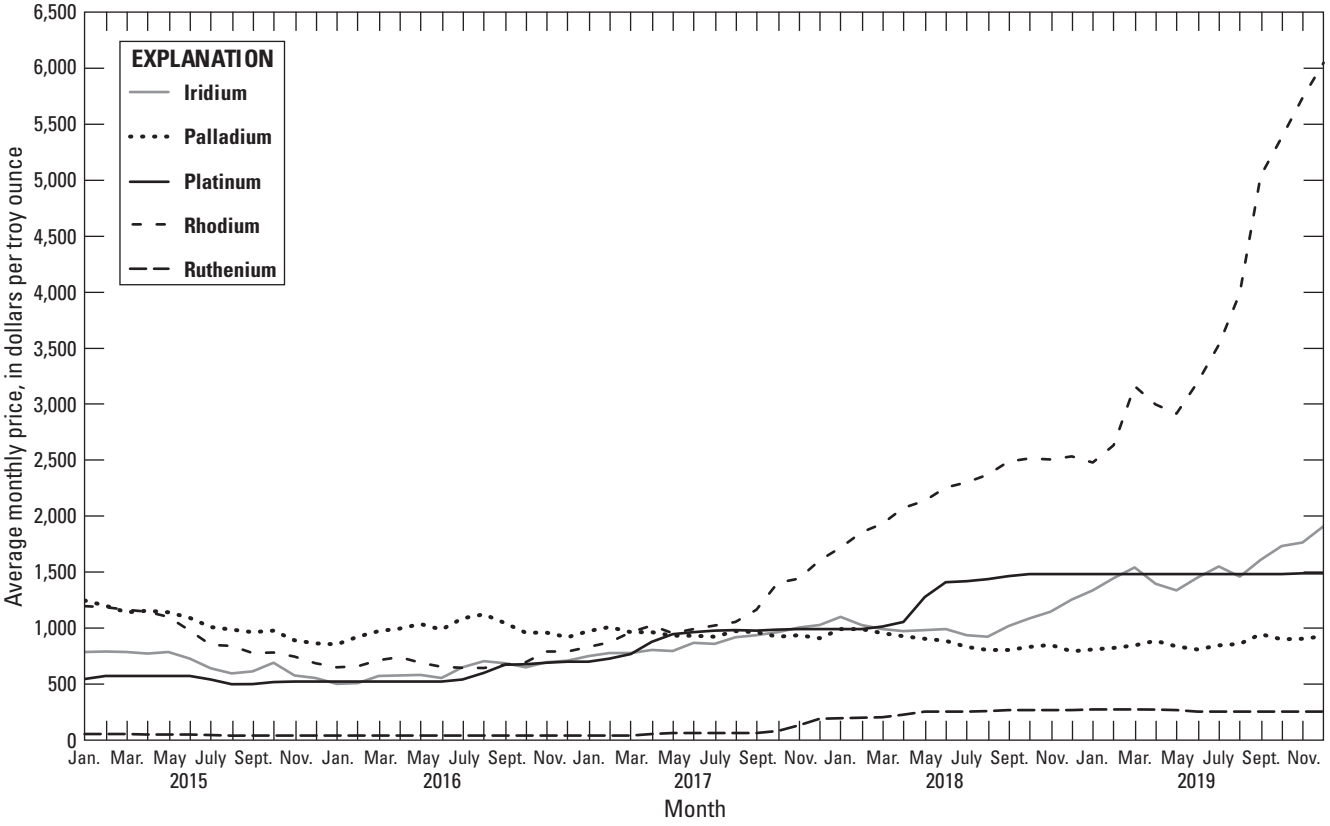

Figure 1. Engelhard unfabricated average monthly prices for the platinum-group metals (iridium, palladium, platinum, rhodium, and ruthenium), January 2015 through December 2019. Source: Platts Metals Week.