

PLATINUM AND PALLADIUM



Indian Minerals Yearbook 2020

(Part- II :Metals and Alloys)

59th Edition

PLATINUM AND PALLADIUM

(ADVANCE RELEASE)

**GOVERNMENT OF INDIA
MINISTRY OF MINES
INDIAN BUREAU OF MINES**

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13 Platinum and Palladium

Platinum Group of Metals (PGM) is a family comprised of 6 metals—platinum, palladium, rhodium, iridium, osmium and ruthenium. They have similar physical and chemical properties and tend to occur together in the same mineral deposits. These six elements are classified into two groups with reference to the specific gravity of gold (19.2). The elements, Ru, Rh, Pd (sp. gr. 12–12.4) are lighter, while the other three specific gravity elements, Os, Ir and Pt are heavier than gold but within the range of 21.0–21.5. Platinum is an extremely rare metal occurring at a concentration of only 0.005 ppm in earth's crust. Major applications of platinum and palladium are in Automotive Sector for emission control and in chemical and petroleum refining.

RESERVES/RESOURCES

Reserves/Resources of PGM in the country as on 1.4.2015 as per NMI Database, based on UNFC System, are placed at 15.71 tonnes of metal content. Reserves/Resources are grouped under Remaining Resources category. By State, Odisha alone accounts for 90% of country's reserves/resources of PGE followed by Karnataka (10%) and Uttar Pradesh with negligible amount (Table-1).

Boula-Nuasahi, a 3 km-long belt, 170 km NE of Bhubaneswar, Odisha, is the only proven Platinum Group of Metals (PGM) deposit in the country. Preliminary assessment of PGMs in Sukinda ultramafic field indicated isolated anomalous values in chromite. Platinum values of 2 to 400 ppb and palladium values of 1 to 500 ppb were established on analysis. The limonite cappings over ultramafic

rocks showed combined platinum and palladium values between 40 and 290 ppb. In Boula-Nuasahi ultramafic complex, the easternmost chromite band known as Shankar-Ganga load, investigations revealed potential PGM mineralisation. In Sittampudi Complex, Salem district, Tamil Nadu, analysis of chromite bands showed 0.03 to 0.75 ppm Pt and 0.1 to 1.0 ppm Pd, whereas amphibolite samples showed 0.03 to 0.05 ppm Pt and 0.03 to 0.5 ppm Pd. A platinum-rich chromite-ferro-chromite breccia zone stretching to about hundred metres in gabbroic matrix was identified in the southern extension of the already known Boula-Nuasahi area in Kendujhar district, Odisha. In Usgaon area, Southern Goa, PGM samples analysed up to 0.03 ppm Pt and 0.03 to 0.15 ppm Pd. In recent past, occurrences of PGE mineralisation were reported in mafic-ultramafic complex of Shivamogga schist belt in Davanagere district of Karnataka. Three zones having 10 to 830 ppb of platinum and 50 to 1500 ppb of palladium were established.

The major part of 15.7 tonnes of metal content UNFC reserves/resources of PGM estimated so far about 14.2 tonnes of metal content of PGM are located in Niligiri, Boula-Nuasahi and Sukinda areas in Odisha and the remaining 1.5 tonnes of metal content of PGM in Hanumalpara area in Shivamogga schist belt of Karnataka. About 49% resources are under Indicated category and the remaining under Inferred and Reconnaissance categories. The reserves/resources of PGM in Uttar Pradesh have been reported here for the first time in consonance with NMI as on 1.4.2015 (Table-1).

Table – 1: Reserves/Resources of PGM as on 1.4.2015

(In tonnes of metal content)

State	Reserves Total (A)	Remaining resources			Total Resources	
		Indicated STD 332	Inferred STD 333	Reconnaissance STD 334	Total (B)	Total (A+B)
India	-	7.71	6.5	1.5	15.71	15.71
Karnataka	-	-	-	1.5	1.5	1.5
Odisha	-	7.7	6.5	-	14.2	14.2
Uttar Pradesh	-	0.01	-	-	0.01	0.01

EXPLORATION & DEVELOPMENT

The exploration and development details, if any, are covered in the Review on Exploration & Development under "General Reviews"

USES

China and India are moving forward with large-scale plans to reduce the amount of carbon emission in their respective countries. Currently, more than half of platinum and palladium mineral goes into making catalytic converters in automobiles. Automobiles that run on diesel predominantly use platinum for catalytic conversion. Platinum-cured silicones are used to coat and protect automotive air bags from their explosive system. The air bags contain an initiator sensor, which uses a fine platinum wire coated with explosive material to facilitate release of the air bag. The chemical inertness and refractory properties of these metals are conducive for their applications in electrical, electronics, dental, medical fields and in the Glass Industry. These metals are also used as catalyst in various chemical processes, viz, in organic synthesis in hydrogenation, de-hydrogenation and isomerisation, production of nitric acid, the raw material for the manufacture of fertilizers, explosives & polymers and fabrication of laboratory equipment.

In addition, platinum, palladium and a variety of complex gold-silver-copper alloys are used as dental restorative materials. The non-corrosive and non-allergic properties of platinum find varied applications in the medical field. Platinum's excellent compatibility with living tissue unaffected by the oxidising reaction of blood, enables its utility in pacemakers.

The primary usage of PGM is in chemotherapy for treatment of cancer. It has the ability to prevent division of certain living cells, a remarkable characteristic which finds profound application in treatment of cancer. Besides, platinum-iridium alloys are extensively used in prosthetics and biomedical devices.

Platinum's excellent conductivity lends itself for use in the electrodes of phosphoric acid fuel cells for generating electricity. Another significant use of platinum and its alloys, in cast or wrought form is in jewellery. Platinum-iridium alloys find major

application in making crucibles for growing crystals. Glass made with platinum and rhodium is used in housing construction, flat screen televisions, computer monitors, display panels, automobile displays, factory monitoring equipment, etc. Recently, a new metallic glass featuring micro-alloys of palladium with silicon, germanium, silver, etc. was reportedly developed at University of California. The glass is characterised by strength and toughness. Platinum is used to enhance storage capacity of devices, such as, computer hard discs, cellphones, digital cameras and personal music players. Recently, palladium-silver resistors have been used in secondary lightning surge protection devices. In Electronic Industry, palladium's use is for Multi-Layer Ceramic Capacitors (MLCC). The effect of miniaturisation of MLCC has not reduced the quantum of palladium used as more number of MLCC are required for the same electronic device. Platinum-based fuel cells are proving to be more cost effective, cleaner and more reliable than alternatives, such as, diesel generators.

Rhodium usage is also on the rise in the Automotive Industry apart from fibre glass. Platinum is the catalyst used by fuel cells to convert hydrogen and oxygen to electricity.

Palladium is also likely to play a role in fuel cells. Platinum acts as an effective and durable catalyst in hydrogen-powered Fuel Cell Electric Vehicles (FCEVs).

SUBSTITUTES

Platinum and palladium are two of the most expensive metals on the planet. Platinum is currently about 30% more expensive than gold while palladium is about half the cost of gold. It is usually easier to substitute metals of the platinum group for one another, especially in alloys, than to use alternative materials, which is evident from the total dominance of ruthenium-based resistors over the palladium-silver resistors for high-powered applications. Substitutes in electrical use include tungsten, nickel, silver, gold and silicon carbide. Alternative catalysts include nickel, molybdenum, tungsten, chromium, cobalt, vanadium, silver and rare earths. Rhenium, however, has been used most satisfactorily as substitute for platinum as a catalyst in petroleum refining. Stainless steel and ceramics can be

substituted where resistance to corrosion is the primary concern. Some motor vehicle manufacturers have substituted platinum by palladium in catalytic converters, especially for petrol engines. Particulate matter and residual sulphur contaminate palladium and hence, it was excluded from catalysts used in diesel vehicles. A new technology now allows up to 25% substitution of platinum in diesel catalytic converters with palladium.

Similarly, manufacturers of electronic parts are also reducing the average palladium content of the conductive pastes used to form the electrodes of multi-layer ceramic capacitors, substituting base metals or silver-palladium pastes which contain significantly less palladium.

Rhenium, tungsten and molybdenum as substitute for platinum in aeromatics hydrogenation catalysts have been investigated. Recently, a new type of iron and carbon-based catalysts has been discovered which is stable and active in both acidic and alkaline media and may even eliminate the need of platinum in catalysts and thus revolutionise the Proton Exchange Membrane Fuel Cell (PEFC) Industry.

TECHNICAL POSSIBILITIES

The spent converters contain platinum and palladium in 3:1 ratio, but heavy shift towards use of palladium to meet stringent emission controls will change this proportion of recovery.

The emergence of Polymer Electrolytic Membrane (PEM) fuel cells developed for passenger cars and trucks will boost prospects of platinum in near future by replacing the high energy battery-operated options for emission controls. The costs of higher range of driving and quick refuelling of fuel cells are, however, 10 times more than the cost of petrol engine.

The development of Solid Oxide Fuel Cell (SOFC) in Japan will eliminate the use of platinum converter as it is compact and gives consistent performance as conversion of conventional fuels into hydrogen is avoided.

Recycling is a significant factor in the supply of many of the metals used in our society. It plays an important role in lowering the environmental foot-print of global PGM production. Over 95% of the PGM content of spent automotive catalysts can be repeatedly recovered. Cellphones are one of the

major sources of secondary metals. Falconbridge Ltd estimated that in 1 tonne of obsolete cellphones (excluding batteries) the average palladium and platinum was about 130 g and 8 g respectively.

RESEARCH & DEVELOPMENT

The Mineral Processing Department of the Institute of Minerals & Material Technology (IMMT), Bhubaneswar (CSIR) had envisaged projects to pursue research focused on recovery of PGE values from the low tenor hosts like Boula-Nuasahi igneous complex by adopting suitable beneficiation tests and development of process flow sheet for recovery of PGE from Indian ores. The methods adopted elsewhere in the world perhaps may not suit in India because the PGE occurs in oxide of chromium and sulphide facies in very fine inclusions & exsolution form.

Bench-scale beneficiation of low-grade PGM samples from T2 sector, Tasampalayam block in Sitampundi Anorthosite complex in Tamil Nadu for GSI was carried out at the Modern Mineral Processing Laboratory and Pilot Plant, IBM, with the objective of enriching platinum group metal present in the sample and to evolve a suitable process flow sheet for recovery of PGM concentrate and chromite. The study indicated that the samples are amenable to beneficiation to produce platinum group of minerals.

WORLD REVIEW

The world reserves of PGM are estimated at 69,000 tonnes concentrated mostly in South Africa (91%) followed by Russia (6%), Zimbabwe (2%) and USA (1%) (Table - 2).

Table – 2 : World Reserves of Platinum Group Metals (By Principal Countries)

(In kilograms of PGM content)

Country	Reserves
World: Total (rounded off)	69,000,000
Canada	310,000
Russia	3,900,000
South Africa	63,000,000
USA	900,000
Zimbabwe	1,200,000
Other countries	NA

Source: USGS. Mineral Commodity Summaries, 2021,

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World mine production of PGMs decreased slightly by 2% to 457 tonnes of metal content in 2019 from 466 tonnes of metal content in 2018 (Table-3).

**Table – 3 : World Mine Production of PGMs
(By Principal Countries)**

Country	2017	2018	2019
World: Total (rounded off)	454000	466000	457000
Canada^(e)			
Platinum ^(e)	9800	11000	10300
Palladium ^(e)	17100	19200	17900
Other platinum metals ^(e)	1100	1300	1200
China			
Platinum	2500	2500	2500
Palladium	1400	1300	1300
Russia			
Platinum ^(a)	22100	20200	21500
Palladium ^(a)	86300	85300	86300
Other platinum metals ^(a)	2400	2100	1835
South Africa			
Platinum	131247	137053	132989
Palladium	80134	80629	80684
Other platinum metals	48895	52964	54395
USA			
Platinum	3980	4160	3600
Palladium	13600	14300	12000
Other platinum metals	100	100	100
Zimbabwe			
Platinum	14257	14703	13856
Palladium	11822	12094	11639
Other platinum metals	3005	3076	2800
Other countries (Platinum Group Metals)	3847	3621	2388

Source: BGS, World Mineral Production, 2015-2019.

(a) Sales from mine production and stocks.

(b) Years ending 7th July of that stated.

South Africa, which accounted for 59% of the total PGM mine production in 2018 was followed by Russia (24%), Zimbabwe & Canada (6% each), USA (3%) while other countries like Finland, Australia, Colombia, Serbia and Poland contributed the remaining 4%. In 2019, world mine platinum production decreased by 3% to 185.01 tonnes of metal content as against 191.21 tonnes of metal content in the preceding year. South Africa which accounted for 71% of world mine platinum production

total at 132 tonnes of metal content, reported about 3% decrease from that in 2018. Global mine production of palladium in 2019 at 211.07 tonnes showed a slight decrease of 2% from 214.58 tonnes in metal content in 2018. Russia accounted for 41% and was followed by South Africa (38%), Canada (8%), USA (7%) and Zimbabwe (6%). A negligible 1% was contributed by other countries.

To provide a generalised view of the development in various countries, the countrywise description, as sourced from the latest available publication of Minerals Yearbook 'USGS' 2017, is furnished below:

Canada

North American Palladium Ltd that produced 6,270 kg of palladium and 382 kg of platinum from its Lac des Isles Mine in Ontario registered a increase of 35% and 20%, respectively as compared to that of the production in 2016. The increase was as a result of resumption of full-time milling operations by the fourth quarter of 2017, with changes in mining methods alongwith upgrades effected to the structure and equipment at the mine.

Russia

PJSC 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 as compared with production in 2016.

Zimbabwe

Zimplats Holdings Ltd 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 the production in 2016. The redevelopment of the Bimha Mine was on schedule and was expected to return to full capacity by the fourth quarter of 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- 6% and 17% less respectively as compared with the production in 2016. Amplats' Bokoni Mine was placed on care-and-maintenance status in the third

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quarter of 2017, and the jointly owned Mototolo Mine was temporarily closed from August to December for safety work.

In 2017, Glencore produced 778 kg of palladium and 1,280 kg of platinum, which reportedly showed a decrease of 31% and 29% respectively.

Production at Implats' South African mining operations in 2017 was about 15,200 kg of palladium and 26,300 kg of platinum. The production essentially remained unchanged for palladium and showed a decrease of 5% for platinum as compared with the production in 2016.

FOREIGN TRADE

Exports

Exports of platinum alloys and related metals decreased substantially by about 36% to 604 kg valued at ₹168.17 crore in 2019-20 from 937 kg valued at ₹219.74 crore in the previous year. Exports were mainly to UK (49%), Switzerland (25%), Japan (8%) and Italy & USA (5% each). Exports in 2019-20 comprised of platinum (unwrought) at 259 kg and platinum (others) at 197 kg. During 2019-20, exports of other metals of

platinum group were 148 kg as compared to 258 kg during the preceding year while that of platinum-powder were nil as compared to 1 kg in the previous year (Tables- 4 to 9).

Imports

Imports of platinum alloys and related metal increased slightly by 5% to 9,299 kg valued at ₹ 2,580.98 crore during 2019-20 as compared to 8,876 kg valued at ₹ 1,833.46 crore in the previous year. Imports were mainly from UK (40%), South Africa (22%), USA (11%) and Germany (10%). Imports in 2019-20 comprised of platinum (powder, unwrought & others) at 4,705 kg, platinum (others) 3,025 kg and other metals of platinum group 1,569 kg. Imports of other metals of platinum group were mainly from UK (45%), Germany (23%), Hong Kong & USA (8% each), and Japan (7%). During 2019-20, imports of platinum-clad base (precious metals) increased by 20% to 6 kg as compared to 5 kg in the previous year. Import were mainly from USA (83%) and UK (17%). During 2019-20, imports of platinum powder were at 666 kg as compared to 578 kg in the preceding year. Imports were mainly from Germany (42%), South Africa (39%), Russia (10%) and USA (7%) (Tables- 10 to 17).

**Table – 4: Exports of Platinum Alloys & Related Metals: Total
(By Countries)**

Country	2018-19 (R)		2019-20 (P)	
	Qty (kg)	Value (₹'000)	Qty (kg)	Value (₹'000)
All Countries	937	2197414	604	1681683
UK	711	1747741	297	801007
Switzerland	-	-	151	327648
Japan	-	-	48	223675
Singapore	++	30	16	96300
Italy	28	73051	31	95619
Germany	++	98	20	74142
USA	152	291726	31	60069
Hong Kong	++	76	10	2532
Israel	++	1104	++	592
Korea, Rep. of	45	82753	++	55
Other countries	1	836	++	44

Figures rounded off

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**Table – 5 : Exports of Platinum (Unwrought)
(By Countries)**

Country	2018-19 (R)		2019-20 (P)	
	Qty (kg)	Value (₹'000)	Qty (kg)	Value (₹'000)
All Countries	394	738216	259	524195
Switzerland	-	-	151	327648
UK	235	450284	64	62668
USA	118	211429	31	60069
Singapore	++	30	5	56760
Italy	2	4597	8	16399
Israel	++	1052	++	592
Bahrain	-	-	++	35
Korea, Rep.of	39	70747	++	14
UAE	-	-	++	9
China	++	14	-	-
Other countries	++	63	-	-

Figures rounded off

**Table – 6 : Exports of Platinum (Others)
(By Countries)**

Country	2018-19 (R)		2019-20 (P)	
	Qty (kg)	Value (₹'000)	Qty (kg)	Value (₹'000)
All Countries	284	614380	197	641513
UK	221	469264	141	426554
Italy	26	68454	23	79220
Germany	-	-	20	62281
Japan	-	-	8	52455
Singapore	-	-	5	21004
USA	31	64568	-	-
Korea, Rep. of	6	12006	-	-
Hong Kong	++	76	-	-
Nepal	++	13	-	-

Figures rounded off

**Table – 7 : Exports of Platinum (Powder)
(By Countries)**

Country	2018-19 (R)		2019-20 (P)	
	Qty (kg)	Value (₹'000)	Qty (kg)	Value (₹'000)
All Countries	1	834	-	-
Kuwait	1	758	-	-
Germany	++	64	-	-
Israel	++	13	-	-

Figures rounded off

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**Table – 8 : Exports of Other Metals of Platinum Group
(By Countries)**

Country	2018-19 (R)		2019-20 (P)	
	Qty (kg)	Value (₹'000)	Qty (kg)	Value (₹'000)
All Countries	258	843984	148	515975
UK	255	828193	92	311785
Japan	-	-	40	171220
Singapore	-	-	6	18537
Germany	++	15	++	11861
Hong Kong	-	-	10	2532
Korea, Rep. of	-	-	++	40
USA	3	15729	-	-
Israel	++	39	-	-
Egypt	++	7	-	-

Figures rounded off

**Table – 9 : Exports of Platinum-Clad Base/Precious Metal
(By Countries)**

Country	2018-19 (R)		2019-20 (P)	
	Qty (kg)	Value (₹'000)	Qty (kg)	Value (₹'000)
All Countries	++	254	-	-
USA	++	191	-	-
Australia	++	63	-	-

Figures rounded off

**Table – 10 : Imports of Platinum Alloys and Related Metals : Total
(By Countries)**

Country	2018-19 (R)		2019-20 (P)	
	Qty (kg)	Value (₹'000)	Qty (kg)	Value (₹'000)
All Countries	8876	18334591	9299	25809819
UK	3453	8002430	3686	11602641
South Africa	1770	3720317	2082	6376221
Germany	1200	3073038	968	3013894
USA	1115	1291904	1055	1650930
Russia	15	10342	214	1086623
Italy	378	458731	557	878768
Switzerland	19	38472	13	375083
Japan	620	1341858	190	328280
Hong Kong	29	43113	157	143135
Belgium	++	4	4	135516
Other countries	277	354382	373	218727

Figures rounded off

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**Table – 11 : Imports of Platinum (Powder, Unwrought & Others)
(By Countries)**

Country	2018-19 (R)		2019-20 (P)	
	Qty (kg)	Value (₹'000)	Qty (kg)	Value (₹'000)
All Countries	4859	9548458	4705	10157861
UK	1960	3887013	2057	4602109
South Africa	1216	2354525	1424	2992174
Germany	810	1563463	608	1262679
USA	478	946871	245	515010
Italy	81	159667	154	309460
Russia	-	-	69	156165
Japan	227	460346	72	137297
Hong Kong	16	32314	31	65198
UAE	8	17424	24	49411
Czech Republic	13	31704	14	49000
Other countries	50	95131	7	19360

Figures rounded off

**Table – 12: Imports of Other Metals of Platinum Group
(By Countries)**

Country	2018-19 (R)		2019-20 (P)	
	Qty (kg)	Value (₹'000)	Qty (kg)	Value (₹'000)
All Countries	1789	4998382	1569	5927791
UK	532	1730937	700	3358174
Germany	385	1508233	359	1750696
USA	156	269475	124	475110
Japan	382	855229	102	117360
South Africa	246	587064	50	81014
Hong Kong	12	10048	126	77937
Singapore	20	13441	98	66727
China	35	1376	10	773
Russia	15	10342	-	-
Switzerland	3	7108	-	-
Other countries	3	5130	-	-

Figures rounded off

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**Table – 13: Imports of Platinum (Others)
(By Countries)**

Country	2018-19 (R)		2019-20 (P)	
	Qty (kg)	Value (₹'000)	Qty (kg)	Value (₹'000)
All Countries	2228	3787752	3025	9724166
UK	961	2384480	929	3642358
South Africa	308	778729	608	3303033
Russia	-	-	145	930458
USA	481	75558	686	660810
Italy	297	299064	403	569308
Switzerland	++	115	13	374164
Belgium	-	-	4	135516
Japan	11	26283	16	73623
Singapore	5	37	60	32359
China	50	20679	160	1698
Other countries	115	202807	1	839

Figures rounded off

**Table – 15 : Imports of Platinum–Unwrought
(By Countries)**

Country	2018-19 (R)		2019-20 (P)	
	Qty (kg)	Value (₹'000)	Qty (kg)	Value (₹'000)
All Countries	4281	8395459	4039	8706425
UK	1960	3886974	2057	4602015
South Africa	1092	2106801	1161	2404616
Germany	495	950487	327	663692
USA	364	708797	197	415504
Italy	81	159667	154	309460
Japan	227	460346	67	128170
Hong Kong	16	32314	31	65198
UAE	8	17424	24	49411
Czech Republic	13	31704	14	49000
Singapore	2	3813	3	5745
Other countries	23	37132	4	13615

Figures rounded off

**Table – 14 : Imports of Platinum-Clad (Rolled etc.)
(By Countries)**

Country	2018-19 (R)		2019-20 (P)	
	Qty (kg)	Value (₹'000)	Qty (kg)	Value (₹'000)
All Countries	5	14391	6	14483
USA	2	5146	5	12444
UK	++	24	1	2039
Singapore	3	8588	-	-
Italy	++	634	-	-

Figures rounded off

**Table – 16: Imports of Platinum–Powder
(By Countries)**

Country	2018-19 (R)		2019-20 (P)	
	Qty (kg)	Value (₹'000)	Qty (kg)	Value (₹'000)
All Countries	578	1152999	666	1451436
Germany	315	612976	281	598987
South Africa	124	247724	263	587558
Russia	-	-	69	156165
USA	114	238073	48	99506
Japan	-	-	5	9127
UK	++	40	++	94
Egypt	25	54186	-	-

Figures rounded off

**Table – 17 : Imports of Platinum-Clad Base/Precious Metal
(By Countries)**

Country	2018-19 (R)		2019-20 (P)	
	Qty (kg)	Value (₹'000)	Qty (kg)	Value (₹'000)
All Countries	5	14391	6	14483
USA	2	5146	5	12444
UK	-	24	1	2039
Singapore	3	8588	-	-
Italy	-	634	-	-

Figures rounded off

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FUTURE OUTLOOK

India is meeting its demand entirely by imports. The demand for PGEs is expected to touch 120 tonnes by 2025, as per the Report of the Sub-group for 12th Plan period.

As per PGM Market Report, February, 2020 of "Johnson Matthey Platinum Group Metals

Service" there has been a decline in demand in 2019 due to sharp falls in Japanese investment buying and Chinese jewellery fabrications. Indian platinum jewellery demand is most likely to expand following successful industry marketing and campaigns to promote the purchase of platinum jewellery sets as wedding gift.

