

PLATINUM AND PALLADIUM



# Indian Minerals Yearbook 2017

(Part- II : Metals & Alloys)

56<sup>th</sup> Edition

**PLATINUM AND PALLADIUM**

**(FINAL RELEASE)**

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

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# 13 Platinum and Palladium

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**P**latinum 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 elements, Os, Ir and Pt are heavier than gold with sp. gr. in 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 PGE 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%) & negligible amount by Uttar Pradesh (Table-1).

Boula - Nausahi, 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-ferrochromite 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.

## EXPLORATION

The exploration and development detail, if any, are given in the reviews on Exploration & Development in "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. The chemical inertness and refractory properties of these metals are conducive for their applications in electrical, electronics, dental, medical fields and 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.

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**Table – 1: Reserves/Resources of PGE Ore as on 1.4.2015**

(In tonnes of metal content)

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

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, cell phones, 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.

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.

## SUBSTITUTES

Platinum and palladium are two of the most expensive metal on the planet. Platinum is currently running about 30% more expensive than gold. Palladium is about half the cost of gold, but its still way up there. 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 aromatics 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, a significant factor in the supply of many of the metals used in our society. Cell phones are one of the major sources of secondary metals. Falconbridge Ltd estimated that in 1 tonne of obsolete cell phones (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 occur in oxide of chromium and sulphide facies in very fine inclusions & exsolution form.

## 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).

In 2016, world mine production of PGMs increased slightly by 1% to 461 tonnes from 455 tonnes in the preceding year (Table-3). South Africa, which

accounted for 57% of the total PGM mine production in 2016. Russia (24%), Canada & Zimbabwe (7% each), USA (4%) and other countries 1%. In 2016 world platinum mine production decreased by only 1% to 187.55 tonnes as against 189.49 tonnes in the preceding year. South Africa which accounted for 71% of world platinum production totalled at 133 tonnes of platinum, about 4% decrease from that in 2015. Global mine production of palladium in 2016 increased by 3% to 208.49 tonnes. Russia accounting for 41% followed by South Africa (37%), Canada (9%), USA & Zimbabwe (6% each). World mine production of other PGMs (iridium, osmium, rhodium and rethenium) increased by 2% in 2016 as compared with that of 2015. South Africa, which accounted for 83% of global production, accounted for most of the increase of other PGMs, Zimbabwe (5%), was the second leading producer.

### Canada

North American Palladium Ltd produced 5,190 kg of palladium and 382 kg of platinum from its Lac des Isles Mine in Ontario registered a decrease of 4% and 6%, respectively as compared to that of the production in 2014. The decreases were attributed to 7-week mill shutdown to correct water balance issues.

### Russia

PJCS MMC produced 81,100 kg of palladium and 19,300 kg of platinum in 2015, marginally less in case of platinum and palladium from the production of 2014.

### Zimbabwe

In 2015, palladium production decreased slightly and platinum production increased slightly as compared to 2014 production. Zimplats Holdings Ltd's, a subsidiary of Impala Ngezi project, a major underground collapse in 2014 resulted in the suspension of mining at the Bimha Mine. Redevelopment of the mine is under progress.

### South Africa

Platinum production in South Africa returned to a normal level in 2015 after the 5 month long working strike in South Africa ended in 2014. Production of Palladium and Platinum increased by 42% and 48% respectively in 2015 as compared to 2014.

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**FOREIGN TRADE**

**Exports**

Exports of platinum and related metals increased drastically by 86 % to 344 kg valued at ₹ 40.40 crore in 2016-17 from 36 kg valued at ₹ 2.13 crore in the previous year. Exports were mainly to UK (39%), Italy (35%) and Japan (16%). Exports in 2016-17 comprised of platinum unwrought at 61 kg & platinum others at 275 kg. During 2016-17 export of other metals of platinum group was 6 kg. During 2016-17 export of platinum-clad base/precious metal was at 5 kg as compared to 10 kg in the previous year. Exports were mainly to Mauritius (40%), Gabon, UK and Sierra Leone (20% each) (Tables- 4 to 9).

**Imports**

Imports of platinum alloys and related metal during 2016-17 decreased by 17% to 7,072 kg valued at ₹ 1,258 crore as compared to 8,536 kg valued at ₹ 1,376 crore in the previous year. Imports in 2016-17 comprised of platinum (powder, unwrought & others) 3,861 kg, platinum (others) 918 kg and other metals of platinum group 2,293 kg. Imports of other metals of platinum group were mainly from South Africa (43%), UK (19%), Switzerland (12%) & USA (10%). During 2016-17 imports of platinum-clad base/precious metal were at 21 kg as compared to 3 kg in the previous year. Exports were mainly to Germany (76%), and USA (14%) (Tables- 10 to 17).

**Table – 2 : World Reserves of PGMs  
(By Principal Countries)**

(In tonnes of metal content)

Country	Reserves
<b>World: Total (rounded off)</b>	<b>69000</b>
Canada	310
Russia	3900
South Africa	63000
USA	900
Zimbabwe	1200

Source: Mineral Commodity Summaries, 2018, USGS

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

(In tonnes of metal content)

Country	2014	2015	2016
<b>World: Total (rounded off)</b>	<b>377.00</b>	<b>455.00</b>	<b>461.00</b>
<b>Botswana</b>			
Platinum	0.12	0.03	-
Palladium	0.56	0.16	-
<b>Canada<sup>(e)</sup></b>			
Platinum	12.00	11.90	11.40
Palladium	21.00	20.80	19.80
Other platinum metals	1.40	1.40	1.30
<b>China<sup>(e)</sup></b>			
Platinum	1.40	1.40	1.40
Palladium	0.70	0.70	0.70
<b>Russia</b>			
Platinum	22.00	20.80	22.50
Palladium	81.30	75.50	86.30
Other platinum metals	2.80	2.50	2.60
<b>South Africa</b>			
Platinum	93.99	139.13	133.24
Palladium	58.41	82.69	76.27
Other platinum metals	36.04	53.70	54.14
<b>USA</b>			
Platinum	3.66	3.67	3.90 <sup>e</sup>
Palladium	12.40	12.50	13.20 <sup>e</sup>
<b>Zimbabwe</b>			
Platinum	12.48	12.56	15.11
Palladium	10.14	10.6	12.22
Other platinum metals	2.67	2.61	3.09
<b>Other countries</b>	<b>3.93</b>	<b>3.33</b>	<b>3.88</b>
(Platinum Group Metals)			

Source: World Mineral Production, 2012-2016, BGS.

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

Country	2015-16 (R)		2016-17 (P)	
	Qty (kg)	Value (₹'000)	Qty (kg)	Value (₹'000)
<b>All Countries</b>	<b>36</b>	<b>21310</b>	<b>344</b>	<b>404007</b>
Italy	8	11677	121	189797
UK	11	2135	133	94647
Japan	-	-	56	90095
USA	4	3204	22	25332
Iran	-	-	2	2536
Israel	1	1398	2	956
Saudi Arabia	-	-	2	384
Singapore	3	211	2	149
Canada	-	-	1	46
Germany	2	17	1	39
Other countries	7	2668	2	26

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

Country	2015-16 (R)		2016-17 (P)	
	Qty (kg)	Value (₹'000)	Qty (kg)	Value (₹'000)
<b>All Countries</b>	<b>19</b>	<b>8184</b>	<b>61</b>	<b>14185</b>
UK	11	2135	52	8307
USA	1	1949	2	4354
Israel	1	1398	2	956
Saudi Arabia	-	-	2	384
Singapore	1	156	1	99
Canada	-	-	1	46
Germany	1	7	1	39
South Africa	1	1352	-	-
Honduras	1	1044	-	-
Hong Kong	1	137	-	-
Other countries	1	6	-	-

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

Country	2015-16 (R)		2016-17 (P)	
	Qty (kg)	Value (₹'000)	Qty (kg)	Value (₹'000)
<b>All Countries</b>	<b>16</b>	<b>13076</b>	<b>275</b>	<b>384725</b>
Italy	8	11677	121	189797
Japan	-	-	56	90095
UK	-	-	81	86340
USA	3	1255	16	18467
Kenya	-	-	1	26
UAE	2	90	-	-
Oman	1	39	-	-
Germany	1	10	-	-
Singapore	1	5	-	-

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

Country	2015-16 (R)		2016-17 (P)	
	Qty (kg)	Value (₹'000)	Qty (kg)	Value (₹'000)
<b>All Countries</b>	<b>1</b>	<b>46</b>	<b>-</b>	<b>-</b>
Singapore	1	46	-	-

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

Country	2015-16 (R)		2016-17 (P)	
	Qty (kg)	Value (₹'000)	Qty (kg)	Value (₹'000)
<b>All Countries</b>	<b>-</b>	<b>-</b>	<b>6</b>	<b>5047</b>
Iran	-	-	2	2536
USA	-	-	4	2511

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

Country	2015-16 (R)		2016-17 (P)	
	Qty (kg)	Value (₹'000)	Qty (kg)	Value (₹'000)
<b>All Countries</b>	<b>10</b>	<b>86</b>	<b>5</b>	<b>414</b>
Mauritius	8	40	2	250
Gabon	1	41	1	77
UK	-	-	1	54
Sierra Leone	-	-	1	33
UAE	1	5	-	-

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

Country	2015-16 (R)		2016-17 (P)	
	Qty (kg)	Value (₹'000)	Qty (kg)	Value (₹'000)
<b>All Countries</b>	<b>3740</b>	<b>7742374</b>	<b>3861</b>	<b>8411508</b>
South Africa	1266	2720078	2262	4940334
UK	373	837048	335	788192
USA	906	1655047	379	728731
Belgium	902	1921753	235	535493
Germany	204	429453	242	532131
Switzerland	8	13638	164	353095
Russia	-	-	91	210072
Italy	33	67026	60	127159
Japan	12	24329	50	107605
Hong Kong	15	28288	15	29356
Other countries	21	45714	28	59340

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

Country	2015-16 (R)		2016-17 (P)	
	Qty (kg)	Value (₹'000)	Qty (kg)	Value (₹'000)
<b>All Countries</b>	<b>8536</b>	<b>13756840</b>	<b>7072</b>	<b>12581542</b>
South Africa	2467	4158651	3404	6476272
UK	1846	2831672	1056	1876023
USA	2116	3111298	792	1173298
Germany	369	664790	458	856949
Switzerland	330	466867	441	766437
Belgium	902	1921753	236	536766
Russia	37	50585	204	367732
Italy	253	248969	210	221480
Japan	146	208830	107	187519
Hong Kong	22	31292	17	31227
Other countries	48	62133	147	87839

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

Country	2015-16 (R)		2016-17 (P)	
	Qty (kg)	Value (₹'000)	Qty (kg)	Value (₹'000)
<b>All Countries</b>	<b>2816</b>	<b>3642786</b>	<b>2293</b>	<b>3165536</b>
South Africa	1174	1432048	989	1303958
UK	731	970073	433	623213
Switzerland	209	330666	276	413327
Germany	147	213442	199	322327
USA	352	422387	223	264152
Russia	36	49492	113	157660
Japan	76	106667	57	79914
Hong Kong	5	549	1	878
China	-	-	1	103
Austria	1	162	1	4
Other countries	85	117300	-	-

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

Country	2015-16 (R)		2016-17 (P)	
	Qty (kg)	Value (₹'000)	Qty (kg)	Value (₹'000)
<b>All Countries</b>	<b>1980</b>	<b>2371680</b>	<b>918</b>	<b>1004498</b>
UK	742	1024551	288	464618
South Africa	27	6525	153	231980
USA	858	1033864	190	180415
Italy	136	65935	150	94321
Spain	19	8244	51	25040
Germany	18	21895	17	2491
Belgium	-	-	1	1273
Hong Kong	2	2455	1	993
China	-	-	60	797
Singapore	2	3818	1	693
Other countries	176	204393	6	1877

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

Country	2015-16 (R)		2016-17 (P)	
	Qty (kg)	Value (₹'000)	Qty (kg)	Value (₹'000)
<b>All Countries</b>	<b>3</b>	<b>736</b>	<b>21</b>	<b>15916</b>
Germany	-	-	16	8734
USA	1	120	3	6352
Italy	1	548	1	717
Russia	-	-	1	113
China	1	68	-	-

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

Country	2015-16 (R)		2016-17 (P)	
	Qty (kg)	Value (₹'000)	Qty (kg)	Value (₹'000)
<b>All Countries</b>	<b>3158</b>	<b>6408993</b>	<b>3499</b>	<b>7623724</b>
South Africa	973	2019171	2127	4646568
UK	351	793663	316	744889
USA	796	1398904	358	681804
Belgium	902	1921753	235	535493
Switzerland	8	13638	164	353095
Russia	-	-	91	210072
Germany	47	96507	55	128343
Italy	33	67026	60	127159
Japan	12	24329	50	107605
Hong Kong	15	28288	15	29356
Other countries	21	45714	28	59340



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

Country	2015-16 (R)		2016-17 (P)	
	Qty (kg)	Value (₹'000)	Qty (kg)	Value (₹'000)
<b>All Countries</b>	<b>582</b>	<b>1333381</b>	<b>362</b>	<b>787784</b>
Germany	157	332946	187	403788
South Africa	293	700907	135	293766
USA	110	256143	21	46927
UK	22	43385	19	43303

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

Country	2015-16 (R)		2016-17 (P)	
	Qty (kg)	Value (₹'000)	Qty (kg)	Value (₹'000)
<b>All Countries</b>	<b>3</b>	<b>736</b>	<b>21</b>	<b>15916</b>
Germany	-	-	16	8734
USA	1	120	3	6352
Italy	1	548	1	717
Russia	-	-	1	113
China	1	68	-	-

## 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 12<sup>th</sup> Plan period. Assuming the success of sustained efforts directed towards mining of the known resources at BNUC (Odisha) and development of a beneficiation flow sheet during the 12<sup>th</sup> Plan, a plant of 2 tonnes per annum capacity can be envisaged by the middle of the 13<sup>th</sup> Plan. The Sub-group recommends that the

preparation of feasibility report in this regard may be assigned to any National Laboratory on priority basis. It expects that an additional 10-20 tonnes per annum should be recovered from recycling by 2017.

As per PGM Market Report, May, 2018 of "Johnson Matthey Platinum Group Metals Service" there has been a decline in demand in 2017 due to sharp falls in Japanese investment buying and Chinese jewellery fabrications.