

## 63 Platinum and Palladium

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Platinum (Pt) and palladium (Pd) are quintessential precious rare metals of the platinum group of metals (PGMs) attributed with immense commercial importance. Platinum is a naturally occurring precious metal that is 35 times scantier than gold. Major applications of platinum and palladium are in automotive sector for emission control and in chemical and petroleum refining.

### RESOURCES

In India, appreciable values of platinum group of elements (PGE) were traced in the Precambrian mafic/ultramafic complexes in Sukinda and Nuasahi sectors of Odisha and Sittampundi in Tamil Nadu. Sampling of chromite ore bodies and their associated rocks revealed occurrence of PGE in these areas. 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 Sittampundi 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 Keonjhar 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 Shimoga schist belt in Davangere 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 UNFC resources of PGMs estimated so far i.e 14.2 tonnes are located in Nilgiri, Boula-Nuasahi and Sukinda areas in Odisha and remaining 1.5 tonnes in Hanumalpur area in Shimoga schist belt of Karnataka. About 49% resources are in pre-feasibility category and the remaining in inferred and reconnaissance category. The resources of PGM, as per UNFC system are given in Table-1.

### EXPLORATION

In Odisha, prospecting stage investigations for PGE values were undertaken by GSI in Bangur & Baniapank in Keonjhar district jointly with Odisha Mining Corporation Ltd (OMC) to assess the extension of chrome-bearing ultramafics in the leasehold areas of OMC Ltd. Depth persistence of chromitite clasts in form of 5 to 8 m wide zones in Bangur underground mine area was confirmed. This area was targeted for further detailed sampling and petrochemical study and 240 geochemical samples were collected.

In Karnataka, in a joint project of GSI & BRGM, anomaly zone over 400 m strike length having width of 23 metres was earlier brought out in Hanumalpur area in Davangere district. After detailed exploration by large scale mapping, drilling and sampling about 1.5 tonnes resources were estimated (Table - 2).

In Tamil Nadu, reconnaissance for PGE values by scout drilling in Tasampalaiyam block of Sittampundi layered complex was initiated to prove depth persistence of PGE in chromitite bodies. Boreholes were drilled in T1 i.e. one of the four sectors along trench section showing high Pt + Pd values. Chromitite chromiferous meta-pyroxenite bands of various dimensions were intersected in all the boreholes. In other sectors close spaced trenches also delineated chromitite and meta-pyroxenite bands. Platinum in native as well as telluride, sulphide and arsenide form was seen in petrographic study.

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**Table – 1: Reserves/Resources of PGM as on 1.4.2010(P)**

(In tonnes of metal content)

State	Reserves Total (A)	Remaining resources			Total (B)	Total resources (A+B)
		Pre-feasibility STD 222	Inferred STD 333	Reconnaissance STD 334		
<b>India</b>	–	<b>7.7</b>	<b>6.5</b>	<b>1.5</b>	<b>15.7</b>	<b>15.7</b>
Karnataka	–	–	–	1.5	1.5	1.5
Odisha	–	7.7	6.5	–	14.2	14.2

**Table – 2 : Details of Exploration Activities for PGM, 2009-10**

Agency/ State/ District	Location/ Area/ Block	Mapping		Drilling		Sampling	Remarks Reserves/resources estimated
		Scale	Area (sq km)	No. of bore- holes	Meterage	(No.)	
<b>GSI, Karnataka</b>							
Davangere	Hanumalpur Block-A	1:1,000	1.75	14	2806	1787	Resources of PGM were estimated at 1.5 tonnes.

In Sathyamangalam block, Tamil Nadu, reconnaissance study in Siviyarpalaiyam area showed four ultramafic (meta-pyroxenite/talc tremolite schist) bands extending over 850 m length were delineated in eastern zone and two bands of 250 m length in western zone. Chemical analysis of samples collected was in progress.

Reconnaissance study was conducted by scout drilling in Solavanur & Karappadi blocks and detailed mapping in Mallanayakanpalaiyam block of Mettuppalaiyam mafic-ultramafic complex. The boreholes in Solavanur block intersected different metapyroxinite bands. Values ranging between 208-801 ppb Pt & 437-1124 ppb of Pd over a width of 3 metres were detected.

In Kerala, reconnaissance for PGE mineralisation in ultramafic rocks of Sulthan Bathery-Mananthavadi of Waynad district was carried out. Pitting, trenching and channel sampling was done in three sub-parallel bands having 10-30 m width and over about 2 km of length in Vakeri area. Chemical & petrographical analysis was in progress. Results are awaited.

In Maharashtra, reconnaissance study for PGE and nickel, cobalt was conducted in basic-

ultramafic intrusives around Gondpipri area of Chandrapur district. Detailed mapping was done in Chek-Vitalwada and Heti areas outlining a 3 m wide zone over 500 m length. Bedrock samples indicated 1037 ppb of PGE & 800 ppm of Ni values. This area has been earmarked for further detailed investigations.

In Madhya Pradesh, reconnaissance study was conducted in mafic and ultramafic rocks of Betul belt in Betul and Chhindwara districts. Mapping was done in Bordehi, Bamla, Padhar, Bijori & Riyatwadi villages. Analysis of samples showed 111 ppb of PGE, about 600 ppm Ni & 0.11-0.24% Cr values.

In Manipur, reconnaissance study was carried out in ophiolite belt where 3 discontinuous lenses of massive chromite were observed within serpentinised ultramafics. The Cr<sub>2</sub>O<sub>3</sub> content was 44-59%.

## USES

Platinum and palladium are primarily used as catalyst in controlling the toxicity of emissions from automobile, chemical and petroleum refining plants. Nearly half of the total platinum is used

as catalysts worldwide in catalytic converters in automobiles. Catalysts for automobile sector use platinum and palladium. 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, d e-hydrogenation and isomerisation, production of nitric acid as also in the manufacture of fertilizers, explosives & polymers and fabrication of laboratory equipment.

Platinum, palladium and a variety of complex gold-silver-copper alloys are used as dental restorative materials. The unique properties of platinum find varied applications in the medical field. Platinum's excellent compatibility with living tissue, as it does not get affected 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 find 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 are 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 silicium, 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 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

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 contaminates 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 multilayer ceramic capacitors, substituting base metals or silver-palladium pastes which contain significantly less palladium.

## 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.

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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 because conversion of conventional fuels into hydrogen is avoided.

### WORLD REVIEW

The largest reserves of PGMs are located in Bushveld Complex in South Africa. The world reserves of PGMs are estimated at 71 thousand tonnes concentrated mostly in South Africa (89%), followed by Russia (9%) and USA (1%) (Table-3).

The world mine production of PGMs slightly decreased to 429 tonnes in 2009 from 440 tonnes in 2008. South Africa continued to be the leading producing country of PGM, contributing about 63% of world production, followed by Russia (26%), USA (4%) and Canada (3%) (Table-4).

Recycling of PGMs was from three main sources i.e. autocatalysts, electronics and jewellery. Globally, the share of autocatalysts and jewellery declined during 2009 due to fall in metal prices, whereas share of electronics doubled as compared to previous year.

In Europe introduction of automobile scrappage plans resulted in increased use of gasoline powered smaller vehicles. Consequently, substitution of palladium for platinum in diesel vehicles was on a reduced scale. This however was offset to some extent by introduction of Euro-V emission standards which needed more amount of PGM in the converters.

About 75% of world consumption of PGMs in jewellery was by China. However, fluctuations in prices of platinum are reflected in this sector.

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

(In tonnes)	
Country	Reserves
<b>World: Total (rounded)</b>	<b>71000</b>
Canada	310
Russia	6200
South Africa	63000
USA	900
Other countries	800

*Source: Mineral Commodity Summaries, 2010.*

*Note: Figures for Colombia, Zimbabwe included with other countries.*

**Table – 4 : World Mine Production of PGMs  
(By Principal Countries)**

(In tonnes of metal content)			
Country	2007	2008	2009
<b>World: Total</b>	<b>487.00</b>	<b>440.00</b>	<b>429.00</b>
<b>Canada<sup>(e)</sup></b>			
Platinum	8.10	7.97	4.67
Palladium	14.10	13.80	8.14
Other platinum metals	0.90	0.90	0.53
<b>Russia</b>			
Platinum	20.98	18.68	18.74
Palladium	88.25	79.97	79.52
Other platinum metals <sup>(e)</sup>	14.50	14.50	14.50
<b>South Africa</b>			
Platinum	165.83	146.14	140.82
Palladium	86.47	75.54	75.12
Other Platinum metals	58.62	54.09	55.45
<b>USA</b>			
Platinum	3.86	3.58	3.83
Palladium	13.31	11.94	12.66
<b>Other Countries</b>	12.09	12.89	15.02

*Source: World Mineral Production, 2005-2009.*

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### South Africa

The production of PGMs during 2009 declined by 1.6% as compared to previous year due to closure of several uneconomic operations, technical problems, labour unrest and smelter problems. South Africa produced 78% of world's platinum, 39% of palladium and 78% of other PGMs (iridium, osmium, ruthenium and rhodium). Output of Mogalakwena Mine of Anglo Platinum increased as a result of commissioning of North Expansion Project in 2008. Pilanesburg mine of Platmin Ltd produced 871 kg of PGM in concentrate in its first year of production. Full capacity of 7,770 kg per year is expected to be achieved by 2011. A joint venture of three companies led by 'Aquarius' produced platinum, palladium and rhodium from chromite talings retreatment plant. Smokey Hills mine of Platinum Australia Ltd started production of PGM in 2009, most of it from opencast operations.

### Zimbabwe

Mimosa's Wedza phase 5.5 expansion was completed in May 2009 increasing the PGM production capacity to 6,220 kg per year. The Phase-I expansion of Impala's Zimplats mine continued and Portal-I reached the full production capacity of 100,000 tonnes per month of ore in June 2009. In July, the Ngezi concentrator was commissioned and was expected to have a capacity of 5,600 kg per annum of platinum-in-matte. Development of Anglo Platinum's Unki mine continued and processing of stockpiled first ore was slated for 2010-end.

## FOREIGN TRADE

### Exports

Exports of platinum alloys and related metals decreased to 10,587 kg valued at Rs. 64 crore in 2009-10 from 36,491 kg valued at Rs. 6,772 crore in the previous year. Exports in 2009-10 comprised unwrought metal, platinum powder and others at 10,216 kg, 290 kg and 80 kg, respectively. Export of other metals of platinum group was only 1 kg to Canada. In 2009-10, There were no exports of platinum-clad base/precious metals (Tables - 5 to 10).

### Imports

Imports of platinum alloys and related metals decreased drastically in 2009-10 to 6,215 kg valued at Rs. 789 crore as against 53,967 kg valued at Rs. 13,680 crore in the previous year. Imports in 2009-10 comprised

platinum powder, unwrought & others 5,024 kg, other metals of platinum group 1,191 kg and platinum others 814 kg. Imports were mainly from UAE (54%), UK (26%), South Africa, Germany and USA (3% each). Besides, there were imports of platinum-clad base/precious metals to the tune of 22 kg in 2009-10 compared to 361 kg during the preceding year. Imports were mainly from UK and Italy (Tables - 11 to 15).

**Table – 5 : Exports of Platinum Alloys & Related Metals : Total (By Countries)**

Country	2008-09		2009-10	
	Qty (kg)	Value (Rs.'000)	Qty (kg)	Value (Rs.'000)
<b>All Countries</b>	<b>36491</b>	<b>67717779</b>	<b>10587</b>	<b>643700</b>
USA	2519	5536459	290	407998
UK	8521	5451566	62	84162
Italy	523	1329700	6	5989
Germany	2240	5367709	4	805
UAE	12885	33242776	3	178
France	490	1118895	–	–
Hong Kong	520	1446210	–	–
Russia	430	1168493	–	–
Spain	378	761902	–	–
Switzerland	780	2056996	–	–
Other countries	7205	10237073	10222	144568

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

Country	2008-09		2009-10	
	Qty (kg)	Value (Rs.'000)	Qty (kg)	Value (Rs.'000)
<b>All Countries</b>	<b>33044</b>	<b>67539158</b>	<b>10216</b>	<b>215423</b>
UK	8519	5450889	52	68469
Italy	515	1328377	6	5989
UAE	12884	33242653	1	127
France	490	1118895	–	–
Germany	2128	5313037	–	–
Hong Kong	520	1446210	–	–
Russia	430	1168493	–	–
Spain	378	761902	–	–
Switzerland	780	2056996	–	–
USA	2423	5438227	–	–
Other countries	3977	10213479	10157	140658

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

Country	2008-09		2009-10	
	Qty (kg)	Value (Rs.'000)	Qty (kg)	Value (Rs.'000)
<b>All Countries</b>	<b>3219</b>	<b>24701</b>	<b>80</b>	<b>19898</b>
UK	2	677	10	15693
China	2207	21548	2	2804
Germany	-	-	4	805
Egypt	-	-	1	382
Canada	-	-	2	172
Chinese Taipei/ Taiwan	-	-	1	21
USA	1	56	20	7
Brazil	1000	975	-	-
Italy	8	1323	-	-
UAE	1	122	-	-
Other countries	-	-	40	14

**Table – 8 : Exports of Platinum (Powder)  
(By Countries)**

Country	2008-09		2009-10	
	Qty (kg)	Value (Rs.'000)	Qty (kg)	Value (Rs.'000)
<b>All Countries</b>	<b>2</b>	<b>1308</b>	<b>290</b>	<b>408537</b>
USA	1	505	270	407991
Netherlands	-	-	17	380
Canada	-	-	1	114
UAE	-	-	2	51
Japan	1	803	-	-
Other countries	-	-	++	1

**Table – 9 : Exports of Other Metals of  
Platinum Group  
(By Countries)**

Country	2008-09		2009-10	
	Qty (kg)	Value (Rs.'000)	Qty (kg)	Value (Rs.'000)
<b>All Countries</b>	<b>226</b>	<b>152612</b>	<b>1</b>	<b>22</b>
Canada	-	-	1	22
Germany	112	54672	-	-
Netherlands	20	269	-	-
USA	94	97671	-	-

**Table – 10 : Exports of Platinum-Clad  
Base/Precious Metal  
(By Countries)**

Country	2008-09		2009-10	
	Qty (kg)	Value (Rs.'000)	Qty (kg)	Value (Rs.'000)
<b>All Countries</b>	<b>65</b>	<b>749</b>	-	-
Italy	34	181	-	-
Oman	20	399	-	-
USA	11	169	-	-

**Table – 11 : Imports of Platinum Alloys and  
Related Metals  
(By Countries)**

Country	2008-09		2009-10	
	Qty (kg)	Value (Rs.'000)	Qty (kg)	Value (Rs.'000)
<b>All Countries</b>	<b>53967</b>	<b>136803700</b>	<b>6215</b>	<b>7893762</b>
UAE	39417	107603307	3359	4903872
UK	2138	2647652	1628	1584662
South Africa	8764	20989046	199	337115
Germany	1098	1027326	202	238580
USA	183	213089	168	175815
Finland	11	16458	64	140978
Russia	172	84671	149	128629
Switzerland	1434	3714170	63	117155
Japan	75	111357	54	59222
Belgium	32	113849	14	30354
Other countries	643	282775	315	177380

**Table – 12 : Imports of Platinum  
(Powder, Unwrought & Others)  
(By Countries)**

Country	2008-09		2009-10	
	Qty (kg)	Value (Rs.'000)	Qty (kg)	Value (Rs.'000)
<b>All Countries</b>	<b>50835</b>	<b>135124436</b>	<b>4210</b>	<b>6938320</b>
UAE	39405	107603066	3254	4853562
UK	935	1915328	411	913287
South Africa	8670	20941864	129	270808
Germany	250	512272	113	228427
Finland	11	16458	64	140978
USA	69	181796	56	130053
Switzerland	1385	3698904	51	115170
Russia	5	9500	41	87168
Japan	20	33086	23	43676
Hong Kong	35	120570	5	10946
Other countries	50	91592	63	144245

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**Table – 13 : Imports of Other Metals Of Platinum Group  
(By Countries)**

Country Name	2008-09		2009-10	
	Qty (kg)	Value (Rs.'000)	Qty (kg)	Value (Rs.'000)
<b>All Countries</b>	<b>3132</b>	<b>1679264</b>	<b>2005</b>	<b>955442</b>
UK	1203	732324	1271	671375
South Africa	94	47182	70	66307
UAE	12	241	105	50310
Russia	167	75171	108	41461
USA	114	31293	112	45762
Japan	55	78271	31	15546
Italy	452	42754	247	41036
Germany	848	515054	89	10153
Switzerland	49	15266	12	1985
Guinea	60	36108	1	95
Other countries	78	105600	13	11412

**Table – 14 : Imports of Platinum (Others)  
(By Countries)**

Country Name	2008-09		2009-10	
	Qty (kg)	Value (Rs.'000)	Qty (kg)	Value (Rs.'000)
<b>All Countries</b>	<b>1440</b>	<b>626160</b>	<b>814</b>	<b>238468</b>
UK	574	375351	421	170031
Italy	393	27361	186	32339
USA	84	22649	79	16701
Germany	99	82828	82	8242
Japan	8	2413	13	4279
South Africa	84	25104	13	3122
Switzerland	49	15266	11	1709
Canada	30	32018	–	–
Russia	72	38333	–	–
Singapore	13	2167	–	–
Other countries	34	2670	9	2045

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**Table – 15 : Imports of Platinum - Clad  
Base/Precious Metal  
(By Countries)**

Country Name	2008-09		2009-10	
	Qty (kg)	Value (Rs.'000)	Qty (kg)	Value (Rs.'000)
<b>All Countries</b>	<b>361</b>	<b>905</b>	<b>22</b>	<b>537</b>
UK	–	–	17	285
Italy	–	–	4	232
USA	22	517	1	20
Germany	339	388	–	–

### **FUTURE OUTLOOK**

The demand for platinum will continue to rise with tighter emission controls, robust growth of automotive sector and electronics and emerging Indian market for platinum jewellery. The demand of palladium is expected to rise as it is increasingly substituted for platinum as catalyst for petrol

engines and to certain extent even in diesel engines. The prospect for rhodium in automotive industry is expected to grow with tighter legislation and increasing vehicle sales. As per the producers of PGMs, development of technology for manufacturing fuel cells, etc. and recovery of global economy will eventually escalate the demand of these metals.