63 Platinum and Palladium

Platinum and palladium 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 Orissa and Sitampudi 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 Sitampudi 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, Orissa. In Usgaon area, Southern Goa, PGM samples analysed up to 0.03 ppm Pt and 0.03 to 0.15 ppm Pd.

The entire resources of PGMs estimated so far at 15 tonnes are located in Nilgiri, Boula-Nuasahi and Sukinda areas in Orissa. About 54% reserves are in pre-feasibility category and the remaining in inferred category. The resources of PGM, as per UNFC system are given in Table-1.

Table - 1: Resources of PGM as on 1.4.2005

(In tonnes of metal content)

State	Reserves	Remaining resources			
	Total (A)	Pre-feasibility STD 222	Inferred STD 333	Total (B)	Total (A+B)
India	**-**	**8**	**7**	**15**	**15**
Orissa	-	8	7	15	15

EXPLORATION

During 2006-07 and 2007-08, GSI carried out exploration for PGM in Tamil Nadu, Karnataka, Maharashtra, Orissa, Meghalaya and Uttar Pradesh. In Karnataka, investigation continued in Hanumalpura block A, block B, block C and block D of Tavaregere -Masanikere - Magyathahalli areas, Davangere district. In block A, 4 boreholes were drilled and a total mineralised zone over strike length of 2.00 km was proved which indicated a resoruce of 0.84 million tonnes of PGE ore containing 0.50 ppm to 2.93 ppm of Platinum + Palladium content. Due to law and order problem depth continuity could not be completed. In block B & C also, geological mapping, trenching and sampling was taken up but this item of investigation was discontinued due to law & order problem. In block D, sampling of bedrocks was completed and analytical results were awaited. Investigations by sampling in the mafic - ultramafic complex of Kaiga-Mothimakki - Biroligudda - Suryakalyanigudda areas in Uttara Kanada district was completed and results were awaited.

In Maharashtra, investigation was taken up by sampling in Khursipar-Manegaon-Dahegaon areas in Gondia district. Xenoliths of titaniferous-vanadiferous magnetite bodies varying in length from 20 m to 430 m and width from 2 m to 40 m were identified. The analytical results were awaited. Another investigation, in Gondpipri area, Chandrapur district was taken up for nickel,

cobalt & PGE where bed rock samples indicted 600 ppm of nickel and 1300 ppm of chromite.

In Meghalaya, priliminry search for PGE in Mawpyut area, East Khasi district continued where large scale mapping delineated podiform bodies of mafic & ultra-mafic rocks. The analytical results of samples were awaited.

In Orissa, investigation in Jamchna-Garsahi area of Baleswar district was conducted and anomalous concentration of PGE (Pt 100 to 300 ppb, Pd 10 to 120 ppb), was found with fractionated part of magnetite gabbro. Suitable locales/traps for PGE enrichment were sampled.

In Tamil Nadu, two investigations for PGE viz, Chettiyampalayam, Tasampalaiyam sector in Namakkal district and Solavanur-Velliyankadu sector of Coimbatore and Erode districts were taken up. In the Chettiyampalayam block which is divided into four sectors (C1, C2, C3 & C4), a prominent mineralised zone was traced for about 900 m strike length, with average grades /width of 1.68 ppm (Pt+Pd)/1.55 m in Eastern part, 1.11 ppm (Pt + Pd)/2.20 m in Central part and 0.70 ppm (Pt + Pd)/1.20 m in Western part. Scout drilling and mapping, trenching, sampling was proposed in this area. Earlier out of 14 samples collected from C1 sector, six showed high values of PGE ranging from 0.31 ppm to 1.78 ppm. In Solavanur - Karappadi Sector, the Solavanur block trench sample yielded 1.39 - 3.15 ppm (total Pt, Pd, Rh, Ir, Ru). Detailed mapping, trenching & sampling revealed three parallel bands out of which the central mineralised band of metapyroxenite was traced for a strike length of 900 m with maximum width of 7 m (average width 2.5 m). Moderate PGE values of 0.24 ppm Pt & 0.52 ppm Pd for a length of 225 m and over a width of 6 m were detected. The maximum value recorded was 0.27 ppm, Pt & 0.86 ppm Pd.

In Uttar Pradesh, investigation was conducted in Kakarwaha area, Lalitpur district and samples were collected from different litho units & the results of chemical analysis were awaited.

USES

Platinum and palladium are primarily used as catalyst in controlling the toxicity of emissions from automobile, chemical and petroleum refining plants. Nearly half the total platinum used worldwide is as catalysts in catalytic convertors 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 and medical fields. 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 as also in 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 and in data storage disks of computers. Glass made with platinum and rhodium is used in housing construction, flat screen televisions, computer monitors, display panels, automobile displays, factory monitoring equipment, etc. 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.

Rhodium usage is also on the rise in the automotive industry. 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 secondary production through recovery of platinum and palladium by recycling automobile catalytic converters is gaining momentum mainly due to rising PGM prices. Presently, 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 membrance (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 reserve base of PGMs is estimated at 80,000 tonnes concentrated mostly in South Africa (87.5%), followed by Russia (8%) and USA (2.5%) (Table-2).

The world mine production of PGMs slightly decreased to 498 tonnes in 2007 from 504 tonnes in 2006. South Africa continued to be the leading producing country of PGM, contributing about 62% of world production, followed by Russia (27%), Canada (5%) and USA (3%) (Table-3).

Table - 2 : World Resources of PGM (By Principal Countries)

(In tonnes)

Country	Reserve base
World : Total (rounded)	**80000**
Canada	390
Russia	6600
South Africa	70000
USA	2000
Other countries	850

Source: *Mineral Commodity Summaries, 2008.*

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

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

(In tonnes of metal content)

Country	2005	2006	2007
World Total	**505.00**	**504.00**	**498.00**
Canada			
Platinum	7.90[e]	8.00[e]	8.10[e]
Palladium	13.80[e]	14.00[e]	14.10[e]
Other platinum metals	0.90[e]	0.90[e]	0.90[e]
Russia			
Platinum	29.00	29.00	23.00
Palladium	97.40	98.40	96.80
Other platinum metals[e]	15.50[e]	15.60[e]	14.50[e]
South Africa			
Platinum	168.75	168.13	165.83
Palladium	84.91	86.27	86.47
Other Platinum metals	58.22	53.14	58.62
USA			
Platinum	3.92	4.29	3.86
Palladium	13.31	14.40	13.31
Other Countries	11.39	11.87	12.51

***Source**: World Mineral Production, 2003-2007.*

WORLD PRICES

The prices of Platinum group of metals were on ascending trend. Platinum registered higher prices than those witnessed in early 1980. Compared to this, the prices of rhodium were in the vicinity of high prices in 1991 and those of palladium were below the peak of US$ 1,082.80/oz in early 2001. The main reason for this was strong demand for use in catalytic converters and investment sector. It was envisaged that these fundamental changes in PGM market may continue into 2008.

FOREIGN TRADE

Exports

Exports of platinum alloys and other metals increased to 1,987 kg valued at Rs. 87 crore in 2007-08 from 659 kg valued at Rs. 63.8 crore in the previous year. Exports in 2007-08 comprised platinum powder, unwrought and others 1,174 kg and other metals of platinum group 813 kg. Exports were mainly to UK (29%), Poland (17%), Hong Kong (14%), Switzerland (9%) and Bangladesh (5%). In 2007-08, about 190 kg of platinum-clad base/precious metal were exported mainly to Netherlands, UK, South Africa and Finland (Tables - 4 to 7).

Imports

Imports of platinum alloys and related metals increased in 2007-08 to 6,468 kg valued at Rs. 624.78 crore as against 6,063 kg valued at Rs. 252.85 crore in the previous year. Imports in 2007-08 comprised unwrought platinum, platinum powder & others 1,985 kg and other metals of platinum group 4,483 kg. Imports were mainly from UK and Germany (25% each), Switzerland (17%), Italy (15%) and South Africa (5%). Besides, there were imports of platinum-clad base/precious metals to the tune of 18 kg in 2007-08 mainly from USA (Tables - 8 to 11).

Table - 4 : Exports of Platinium Alloys & Related Metals : Total (By Countries)

Country	2006-07		2007-08	
	Qty. (kg)	Value (Rs. '000)	Qty. (kg)	Value (Rs. '000)
All Countries	**659**	**638143**	**1987**	**870092**
Hong Kong	222	280536	273	427877
UK	14	31011	568	239646
Switzerland	173	117502	177	71378
USA	47	60450	58	66287
Bangladesh	-	-	100	30536
Japan	11	19460	15	20188
Poland	-	-	339	11350
Germany	160	96646	1	8
France	4	5887	1	++
UAE	6	22291	-	-
Other countries	22	4360	455	2822

Table - 5 : Exports of Platinum (Powder, Unwrought & Others) (By Countries)

Country	2006-07		2007-08	
	Qty. (kg)	Value (Rs. '000)	Qty. (kg)	Value (Rs. '000)
All Countries	**597**	**592227**	**1174**	**829635**
Hong Kong	167	253225	219	399540
UK	14	31011	568	239646
Switzerland	173	117502	176	70907
USA	42	60310	58	66287
Bangladesh	-	-	100	30536
Japan	11	19460	15	20188
France	4	5887	1	++
Germany	160	96646	-	-
Saudi Arabia	8	1707	-	-
UAE	4	3826	-	-
Other countries	14	2653	37	2531

Table - 6 : Exports of Other Metals of Platinum Group (By Countries)

Country	2006-07		2007-08	
	Qty. (kg)	Value (Rs. '000)	Qty. (kg)	Value (Rs. '000)
All Countries	**62**	**45916**	**813**	**40457**
Hong Kong	55	27311	54	28337
Poland	-	-	339	11350
Switzerland	-	-	1	471
Italy	-	-	310	213
South Africa	-	-	5	31
Singapore	-	-	100	28
Baharain	-	-	1	13
Germany	-	-	1	8
UAE	2	18465	-	-
USA	5	140	-	-
Other countries	-	-	2	6

Table - 7 : Exports of Platinium - Clad Base / Precious Metal (By Countries)

Country	2006-07		2007-08	
	Qty. (kg)	Value (Rs. '000)	Qty. (kg)	Value (Rs. '000)
All Countries	**170**	**102832**	**190**	**2069**
UK	-	-	75	1430
Netherlands	-	-	80	423
South Africa	-	-	25	168
Finland	-	-	10	48
Germany	170	102832	-	-

Table - 8 : Imports of Platinium Alloys & Related Metals (By Countries)

Country	2006-07		2007-08	
	Qty. (kg)	Value (Rs. '000)	Qty. (kg)	Value (Rs. '000)
All Countries	**6063**	**2528538**	**6468**	**6247752**
Switzerland	119	6519	1126	2997156
UK	726	459961	1606	1145122
Germany	2468	791703	1587	830402
South Africa	335	422975	336	446067
USA	623	307617	200	229721
UAE	3	765	80	212393
Saudi Arabia	128	304517	74	147152
Russia	105	52552	162	74997
Japan	6	10352	249	73532
Italy	1133	47747	977	38971
Other countries	417	123830	71	52239

Table - 9 : Imports of Platinum (Powder, Unwrought & Others) (By Countries)

Country	2006-07		2007-08	
	Qty. (kg)	Value (Rs. '000)	Qty. (kg)	Value (Rs. '000)
All Countries	**881**	**1368874**	**1985**	**4774955**
Switzerland	1	1615	1080	2992245
UK	136	192498	234	462723
South Africa	171	325446	224	403961
Germany	245	235897	192	377968
UAE	-	-	74	212071
Saudi Arabia	128	304517	74	147152
USA	154	243574	76	136016
Canada	25	39557	10	15912
Japan	4	7327	7	10576
Hong Kong	5	7623	3	4266
Other countries	12	10820	11	12065

Table - 10 : Imports of Other Metals of Platinum Group (By Countries)

Country	2006-07		2007-08	
	Qty. (kg)	Value (Rs. '000)	Qty. (kg)	Value (Rs. '000)
All Countries	**5182**	**1159709**	**4483**	**1472797**
UK	590	267463	1372	682399
Germany	2223	555806	1395	452434
USA	469	64043	124	93705
Russia	105	52552	161	72968
Japan	2	3025	242	62956
South Africa	164	97529	112	42106
Italy	1130	44541	974	33607
China	1	42	9	14238
Norway	90	43092	10	4959
Swaziland	184	11052	8	921
Other countries	224	20564	76	12504

Table - 11 : Imports of Platinium - Clad Base /Precious Metal (By Countries)

Country	2006-07		2007-08	
	Qty. (kg)	Value (Rs. '000)	Qty. (kg)	Value (Rs. '000)
All Countries	**41**	**7753**	**18**	**1478**
USA	-	-	17	1082
Germany	-	-	1	396
China	1	47	-	-
U K	40	7706	-	-

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. There is a need for application of state-of-the art technology and integrated multidisciplinary approach for exploration in the country. 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. will eventually escalate the demand of these metals.