NIMS-EMC MDE Report No.3

Worldwide Supply and Demand of Platinum Group Metals **and Trends in the Recycling of Autocatalyst in Japan**

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1. Summary of results, background, purpose, and method

1.1 Summary of results

(1) Comparison of maximum and minimum price of platinum group metals

The ratio of maximum to minimum price for platinum group metals are as follows: Pt: 28.93/6.55 = 4.42; Pd: 33.34/1.78 = 18.73; Rh: 171.93/5.88 = 29.25. Low ratios reflect a large amount natural reserved and/or a variety of market sector which suppress severe fluctuations in the price.

(2) Price trends in platinum group metals

The price of platinum peaked at $28.93/gram in February 1980. This was a result of decreasing supplies from Russia and increasing demand for platinum as a component of autocatalyst in 1978, which was also the year that the three-way catalyst became practical for simultaneously reducing HC、CO and NOx gases in automobile exhaust.

The price of rhodium (Rh) peaked at $68.52/gram in January 1991. The price had been very low until 1990, but its use in autocatalyst began to increase in North America, Japan, and Europe. At first, there was little use of Rh in autocatalyst, but it gradually came into widespread use so that by 1991, more than 80% of Rh was being used in autocatalyst.

The price of palladium (Pd) peaked at $33.34/gram sharply in 2001. The reason for this sudden rise was due to the effect of Pd in removing hydrocarbons (HC) from automobile exhaust. And it isi proper note that these demand increased, and supplies from Russia became unstable.

(3) Applications of platinum group metals

Platinum is used mainly for autocatalyst and jewelry; little is used for other purposes. A low price of jewelry acts as a triggering mechanism for its purchase which buffers it against sudden drops in price. Palladium is used in autocatalyst, electronics and dental. The 2001 price escalation of Pd first led to reduced demand for the metal in electronics, and soon in other sectors as well. More than 80% of Rh is used in autocatalyst.

(4) Recycling of used platinum group metals

	2000		2001	
	Collected by the UCRA	Present investigation (estimate)	Recovered by the UCRA	Present investigation (estimate)
Pt	4,2t	5.079t	4.8t	5.067t
Pd	12,5t	1.369t	13.9t	1.355t
Rh	0.810t	1.083t	0.887t	1.056t

Source: Statistical data from the Used Catalyst Recycling Association (UCRA)

The reason why Pd has the largest value for collection by the UCRA is because most of the Pd is used for things besides autocatalyst (for example, chemicals, petroleum, electronics). In other words, the recycling of Pd is much more than just the recycling of autocatalyst. One reason why Pt and Rh values are so low may be because there are the data dropped out in the UCRA's statistical data (a part of nonferrous smelters do not belong to the UCRA). There may also be some errors in the estimated values in this report.

(5) Trends in autocatalyst demand by region

In 1996, 1.00-1.3 gram of precious metals was used by each car in Japan, but that figure started rising the next year, reaching 2.88 gram/vehicle in 2002. In North America, the average amount of precious metals per vehicle was 2 grams in 1993 (about twice as much as in Japan). It peaked at 7.08-7.09 gram per vehicle in 1998-99, but by 2002 had fallen back

to the 2.73 gram/vehicle level. Up to 1990, the amount in Europe was an average of 1 g/vehicle, but in 1991 the figure started to rise dramatically, reaching 5.42 gram/vehicle in 2002, .

1.2 Background and purpose

.Regarding the recycling of precious metals including those in autocatalyst, the Used Catalyst Recycling Association publishes some information, but is not limited to automobiles. Therefore, a new investigation is required to understand the recycling of autocatalyst, especially in Japan.

In order to achieve this goal, it is necessary to know something about the trends in the supply and demand of platinum group metals. For that reason, we have compiled information on the recycling of autocatalyst in Japan of together with "Recent Trends in the Supply and Demand of Platinum Group Metals."

1.3 Method for surveys

The following data were used both to understand of the supply and demand of platinum group metals and to estimate the amounts of these metals that are recycled from autocatalyst in Japan.

(a) Recent trends in the supply and demand of platinum group metals are based on platinum data from Johnson Matthey.

(b) Data on the volume of the vehicle production and the number of vehicle discarded from data of the Japan Automobile Manufacturers Association (JAMA).

(c) the amount of platinum scrap imported into Japan was taken from Japan Exports &Import statistics autocatalyst by the Finance Ministry'.

(d) Information on the state of recycling of autocatalyst from the vehicle discarded was obtained from interviews with four dismantler-auto machine parts recycler (3 in the Kanto region, 1 in the Kansai region).

It should be noted that the figures used in the present report are the same as the original table for references cited an the end of this report.

2. Worldwide Trends in the Supply and Demand of Platinum Group Metals

In order to understand the state of autocatalyst recycling, we must know about the upstream processes, that is, the supply and demand of auto exhaust catalysts. But in order to have this information, we have know about worldwide trends in the supply and demand of platinum group metals, which constitute the main metals used in autocatalyst.

2.1 Trends in the prices of platinum group metals and the constituents of major resources

As we can see in Table 2-1-2, there are several members of the platinum group, including platinum (Pt), palladium (Pd), rhodium (Rh), iridium (Ir), ruthenium (Ru), and osmium (Os). However, for purposes of this report, we shall limit the discussion to Pt, Pd, and Rh, which are the main Pt group metals used in autocatalyst. Figure 2-1-1 shows graphs of statistical data of price trends in the platinum group taken at one-month intervals from January 1978 to February 2004. Table 2-1-1 shows the data broken down into small blocks for the minimum and maximum price regions for Pt, Pd and Rh.

Figure 2-1-1 Trends in the prices of platinum group metals

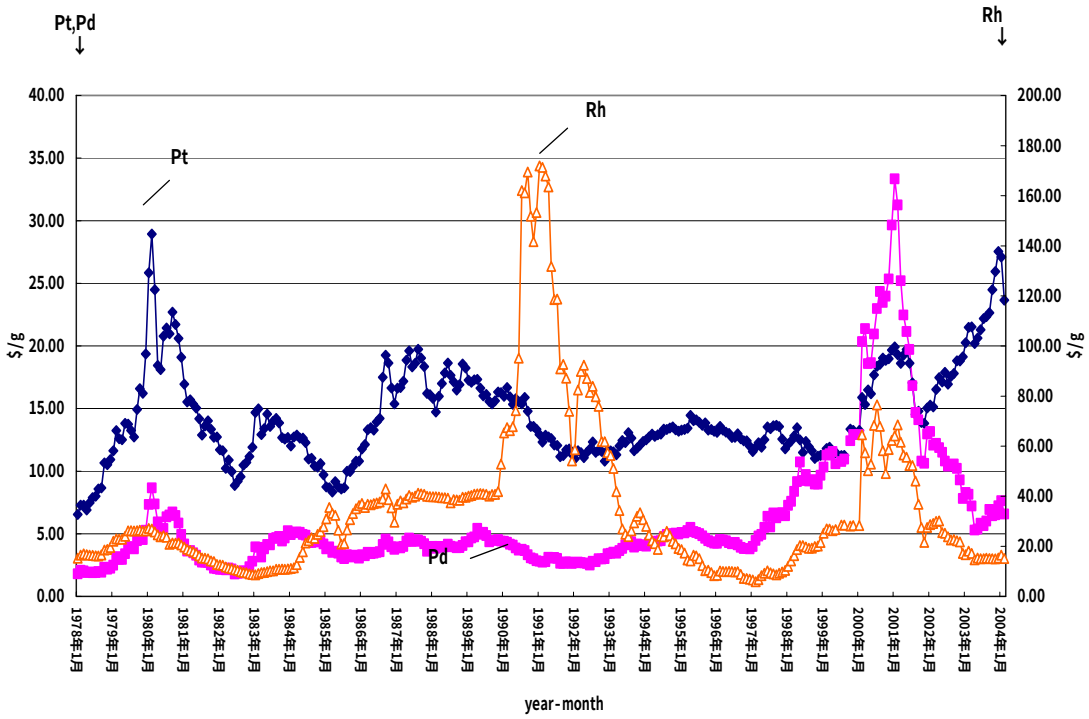


Table 2-1-2 Estimated the constituents of major resources containing platinum group metals

(unit: wt%)

Metal	Columbia	Canada	South Africa		Soviet Union	United States	
	Alluvial platinum	Sudbury	Merensky	Bushveld	Norilisk	Stillwater	Duluth
Pt	93	43	61	47	25	20	18
Pd	1	45	26	32	67	78	78
Ir	3	2	1	2	2		1
Rh	2	4	3	7	3	1	2
Ru	Trace	8	8	11	2		1
Os	1	1	1	1	1	ND	ND

ND: No detection
Source: Mineral Facts and Problems, 1985 Edition, Bureau of Mines Bulletin 675, p.597

Table 2-1-1 Movements in the prices of platinum group metals (maximum - minimum)

No		$/g			No		$/g		
		Pt	Pd	Rh			Pt	Pd	Rh
	Jan-78	**6.55**	**1.81**	15.24		May-96	13.00	4.29	10.04
	Feb-78	7.29	2.07	16.54		Jun-96	12.69	4.21	9.97
	Mar-78	7.29	2.03	17.01		Jul-96	12.72	4.30	9.81
	Apr-78	6.90	1.90	16.66		Aug-96	12.99	4.12	9.91
	May-78	7.49	1.94	16.48		Sep-96	12.59	3.92	8.85
1	Jun-78	7.89	1.88	16.43	5	Oct-96	12.44	3.82	7.21
	Jul-78	8.00	1.91	16.28		Nov-96	12.43	3.81	7.16
	Aug-78	8.59	1.98	16.14		Dec-96	12.00	3.80	6.91
	Sep-78	8.67	1.92	16.59		Jan-97	11.57	3.99	6.58
	Oct-78	10.66	2.34	18.53		Feb-97	11.90	4.46	**5.88**
	Nov-78	10.52	2.17	18.82		Mar-97	12.27	4.81	6.68
	Dec-78	10.93	2.23	19.59		Apr-97	11.92	4.95	8.29
						May-97	12.51	5.51	9.28
	Dec-79	19.36	5.29	26.22					
	Jan-80	25.85	7.35	27.23		May-00	16.19	18.65	52.85
	Feb-80	***28.93***	8.67	26.88		Jun-00	17.68	20.95	68.32
	Mar-80	24.48	7.38	25.80		Jul-00	18.38	22.98	76.56
	Apr-80	18.44	5.95	24.60		Aug-00	18.54	24.35	68.00
	May-80	18.10	5.09	23.86		Sep-00	19.02	23.47	58.27
2	Jun-80	20.77	5.42	24.27	6	Oct-00	18.84	23.98	49.03
	Jul-80	21.43	6.36	23.67		Nov-00	18.97	25.35	58.68
	Aug-80	20.98	6.50	20.86		Dec-00	19.66	29.66	62.29
	Sep-80	22.70	6.74	21.34		Jan-01	19.92	***33.34***	64.10
	Oct-80	21.71	6.46	21.30		Feb-01	19.29	31.27	***68.52***
	Nov-80	20.59	5.86	21.40		Mar-01	18.61	25.22	61.57
	Dec-80	19.10	4.93	20.60		Apr-01	19.26	22.47	56.46
						May-01	19.72	21.15	55.62
	Mar-82	10.22	2.12	11.78					
	Apr-82	10.89	2.26	11.37		Feb-03	21.49	8.16	18.12
	May-82	9.97	2.19	11.15		Mar-03	21.53	7.23	17.20
	Jun-82	8.87	**1.78**	10.69		Apr-03	20.19	5.30	14.67
	Jul-82	9.20	1.84	10.38		May-03	20.63	5.39	15.40
3	Aug-82	9.56	1.87	9.88	7	Jun-03	21.28	5.84	15.07
	Sep-82	10.49	2.05	9.60		Jul-03	22.19	5.64	15.11
	Oct-82	10.70	1.97	9.40		Aug-03	22.34	6.01	15.31
	Nov-82	11.17	2.36	9.00		Sep-03	22.65	6.93	15.15
	Dec-82	11.92	2.81	8.78		Oct-03	24.48	6.45	15.11
	Jan-83	14.69	3.95	**8.64**		Nov-03	25.95	6.51	14.98
	Feb-83	14.98	3.92	9.20		Dec-03	***27.53***	7.24	15.39
	Mar-83	12.92	3.15	9.54		Jan-04	27.11	7.65	16.48
						Feb-04	23.65	6.58	15.18
	Jul-90	15.37	3.77	162.06					
	Aug-90	15.88	3.66	161.21	出典：Platinum： NYMEX Nearby(Metals Week) Paladium： NYMEX Neaby(Metals Week) Rhodium ：MW NY Dealer(Metals Week)				
	Sep-90	14.79	3.32	169.47					
	Oct-90	13.57	3.07	151.77					
	Nov-90	13.57	2.99	141.62					
4	Dec-90	13.34	2.85	153.32					
	Jan-91	12.92	2.80	***171.93***					
	Feb-91	12.31	2.74	171.33					
	Mar-91	12.86	2.78	167.91					
	Apr-91	12.73	3.12	163.53					
	May-91	12.60	3.06	131.78					
	Jun-91	12.09	3.11	118.56					
	Jul-91	12.06	3.04	118.74					

Note: The above blocks have been sectioned from the maximum and/or minimum value period for Pt group metals between January 1978 and February 2004. The bold numbers in Italics denote the maximum value, while normal bold numbers denote minimum value. For example, No.1 shows minimum values for Pt and Pd; No.2 shows the maximum value for Pt; No.3 shows minimum values for Pd and Rh; No.4 shows the maximum value for Rh; No.5 shows minimum values for Rh; No.6 shows minimum values for Pd; No.7 shows the maximum value for Pt.

(1) Peaks of platinum price

As we can see in Figure 2-1-1, the first peak (on the left side) shows Pt at US $28.93/ gram in February 1980, with a second peak $27.53/gram in December 2003. The minimum value for Pt was $6.55/gram in January 1978. The maximum value was 4.42 times higher than the minimum price during this period.

(2) Peaks of rhodium price

The second peak on the right side shows Rh at $171.93/gram in January 1991, with a secondary minimum value of $8.64/gram in January 1983 and a minimum value of $5.88/gram in February 1997. Thus, the maximum value was 29.25 times higher than the minimum during this period.

(3) Peaks of palladium price

The third peak on the right side of Figure 2-1-1 shows Pd at $33.34/gram in January 2001. The secondary minimum value of $1.81/gram occurred in January 1978 and the primary minimum value of $1.78/gram occurred in June 1982. Thus, the maximum price was 18.73 times higher than the minimum price.

2.2 Trends in supply, demand, and price of platinum group metals

The causes for the occurrence of peaks of the Pt group metals listed below are explained in terms of supply and demand data.

(1) Relationship between supply/demand and price fluctuations of platinum

As can be seen in the regional supply chart for Pt (Figure 2-2-1-1), the Pt peak of

$28.93/gram that occurred in February 1980 is the result of an unbalance in supply and demand that was triggered by the decline in Russian supply that started in 1979, and the increase in Pt demand in the United States that began in 1978 with the increased use of autocatalyst (Fig. 2-2-1-3). 1978 was also the year in which the "triple catalyst" was first put to practical use to simultaneously reduction of HC, CO and Nox.

As is clearly seen in the chart for world demand for Pt by use (Fig. 2-2-1-2), more than 80% of Pt demand was for jewelry and autocatalyst, with the remaining uses being divided among electronics (hard disk memory) and crucibles for fusing glass (recently for liquid crystal devices).

Most of the jewelry is used in Japan and China. Before 1995,in Japan the overwhelming majority of this jewelry demand, but as we can see in Figure 2-2-1-4, World supply of Pt for other uses (where "other" means regions besides Japan, Western Europe, North America),the most of the jewelry demand is in China. There, demand has been increasing since 1996 and has reached the point where it now exceeds demand in Japan.

Figure 2-2-1-5 shows that jewelry uses in Japan have been declining since 2000, but this is because of decreasing purchases due to steadily increasing prices. To put it another way, when the price of Pt decreases, purchases of the metal increase, so the metal is buffered against excessive declines in price. The Pt used in jewelry can also be used for industrial purposes, so Pt jewelry can be interpreted to be a sort of “stockpile” of the metal.

The recent increases in world demand for Pt for autocatalyst can be attributed to the following: The rapid increase in the price of Pd in 2001 led to increased consumption of the alternative metals Pt and Rh. At the same time, Pt was increasingly being used in autocatalyst for the growing number of diesel-powered vehicles, particularly in Europe, as

an effective means of reducing unburned hydrocarbons.

Figure 2-2-1-1 World supply of Pt by region (Unit: tons)

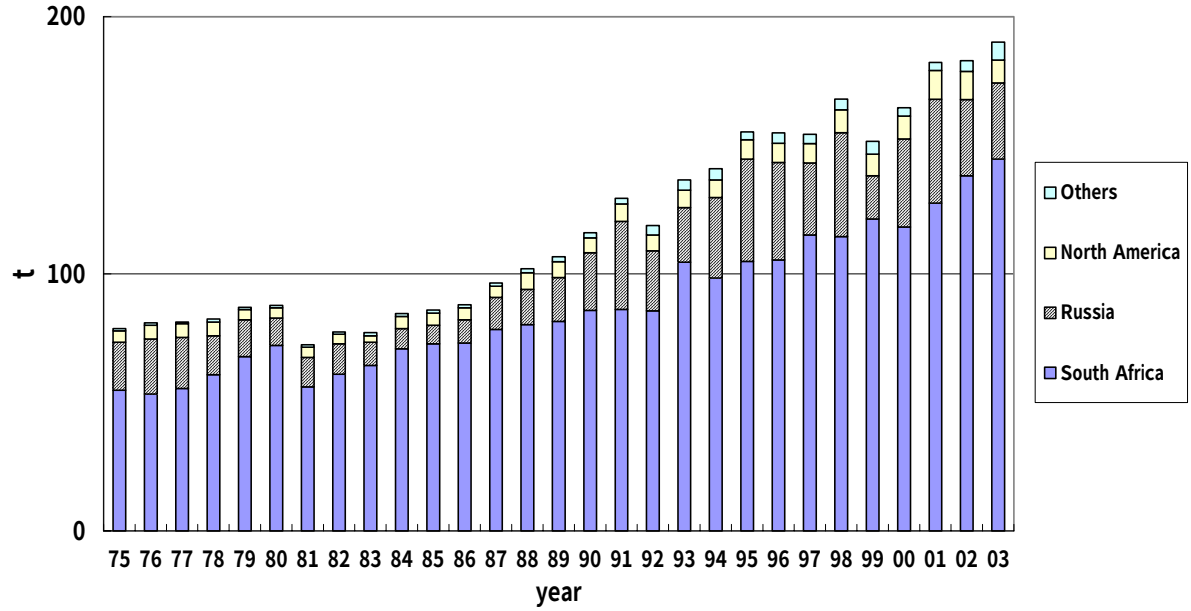


Figure 2-2-1-2 World demand of Pt by market sector (Unit: tons)

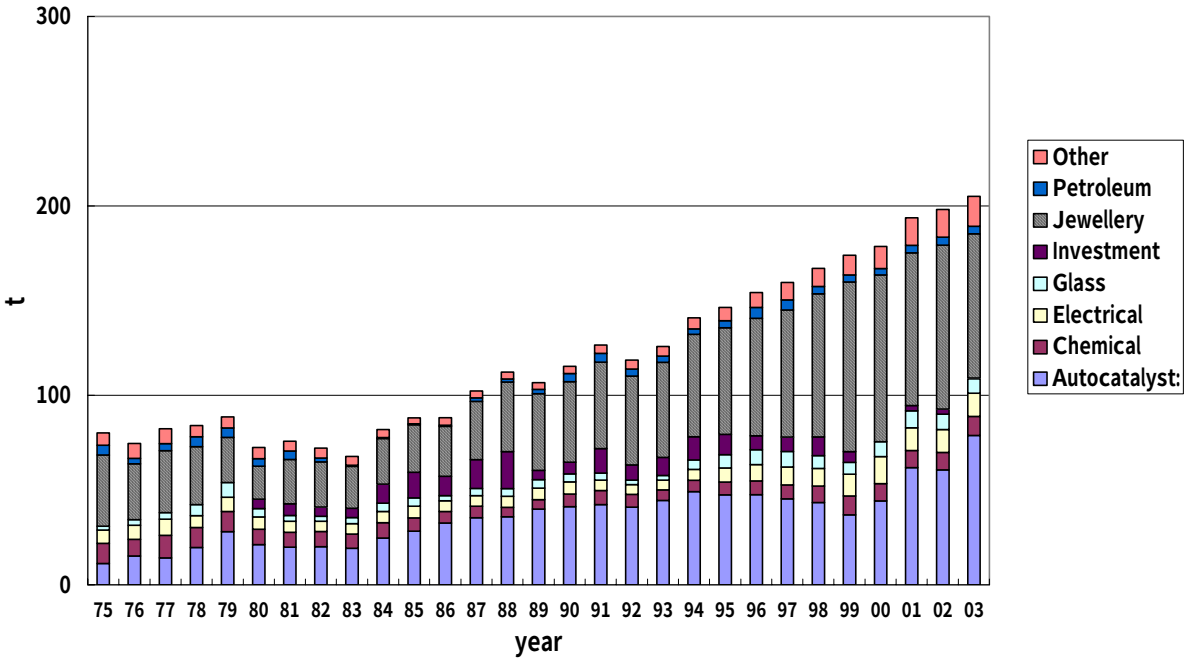


Figure 2-2-1-3 World demand of Pt by region (Unit: tons)

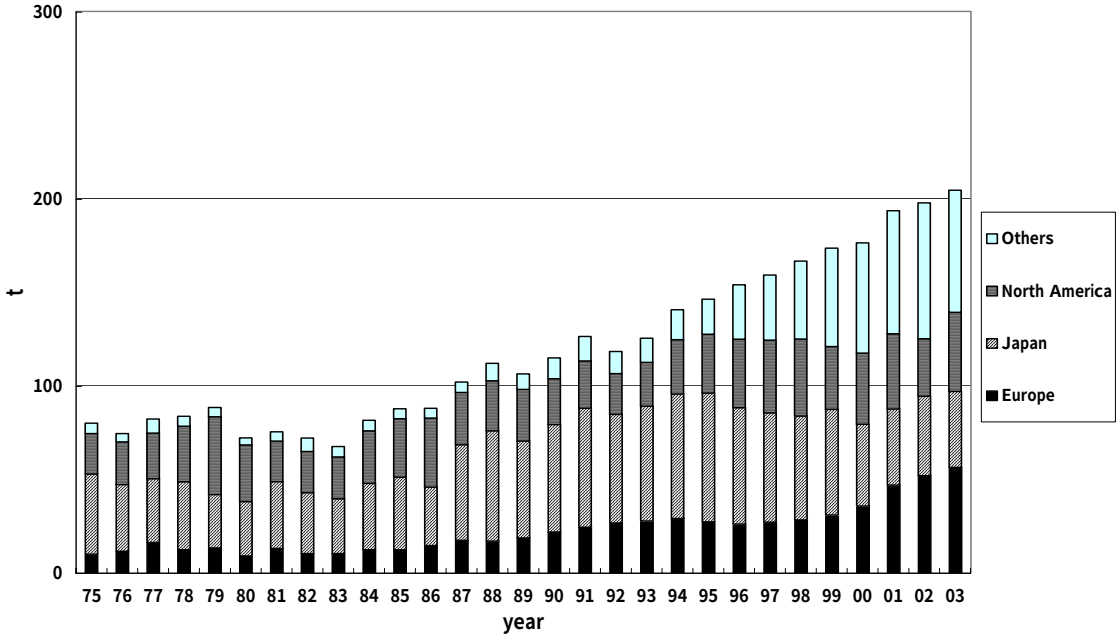


Figure 2-2-1-4 World of other region demand of Pt by market sector (other region : excluding Western Europe, North America, and Japan) (Unit: tons)

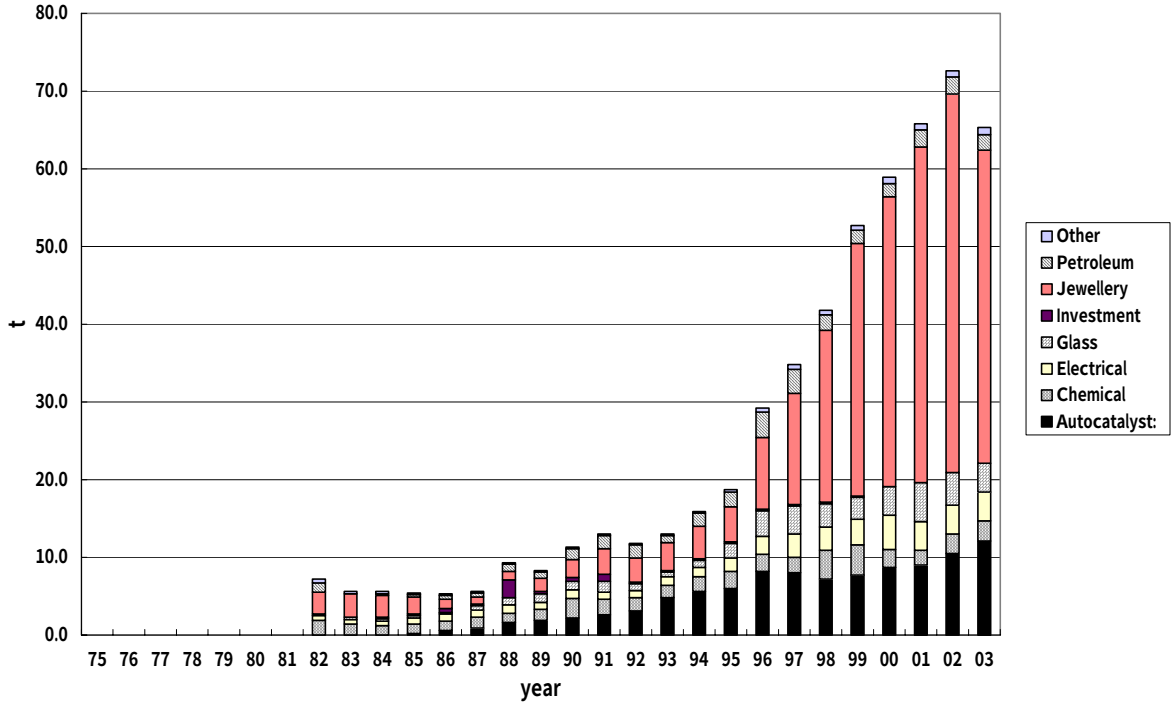
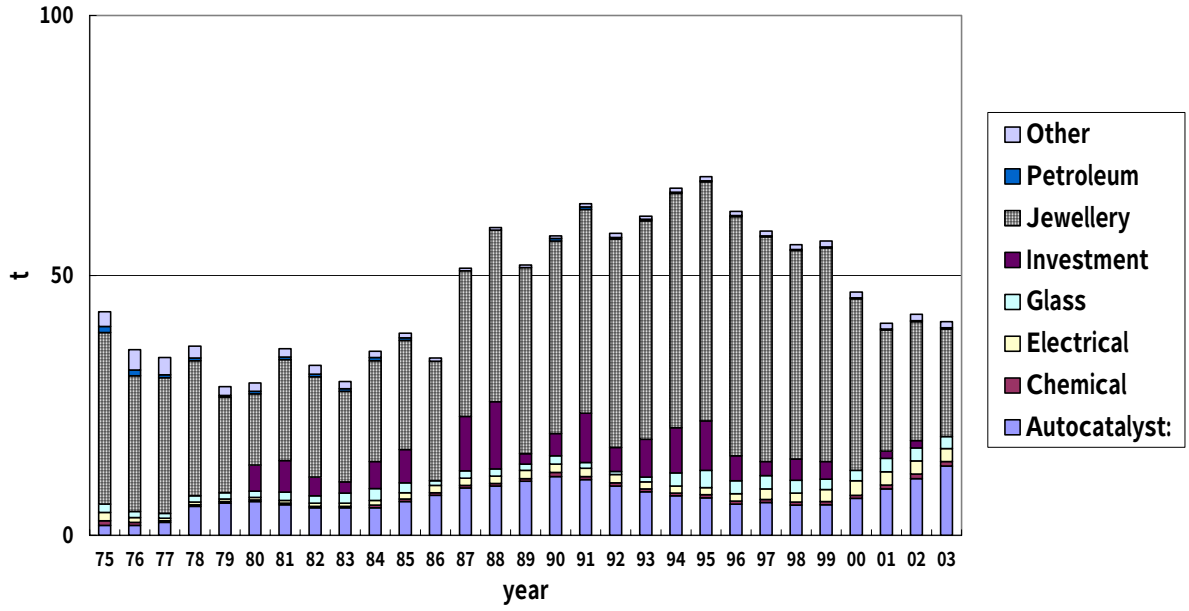


Figure 2-2-1-5 Japanese demand of Pt by market sector (Unit: tons)



(2) Trends in the supply/demand and price fluctuations of palladium

The price of Pd reached a peak in January 2001. The reason for this rapid price increase was the metal's effectiveness in removing hydrocarbons from automobile exhaust. While demand rose for Pd, there was a sense that the supply from Russia become unstable.

As we can see in both Figure and Table 2-2-2-1, Russia supplies more Pd than South Africa; the only time the opposite was true was in 2002. This is because, as shown in Table 2-1-2, the percentage of Pd contained in the platinum group ores from Norilisk is very high. From the yearly ore production at Norilisk and the average Pd contents of the ores, it appears that the mine produces about 30-40 t of Pt, and 50-60 t of Pd per year (Russian government data).

Looking at Table 2-2-2-1 (addendum), we can see that sales of Russian Pd exceeded 100 t from 1994 to 2000, inclusive. It is believed that during this time, Russia was selling from its reserves. Starting in 1997 or so, it looked like Russia might suddenly exhausted reserves, so there was a sense of impending crisis in the market and the price rose, apparently triggering the price explosion that began in 2000. There are plans to increase Pd production by 62 t over a 10-year period (beginning in 2001), especially in South Africa, but this does not take into account the possibility that Russian supplies might quickly exhaust. The impetus for replacing Pd as the price rose occurred in 2001 at Japan MLCC (Multi-layered ceramic condensers), where Pd in conductive layers began to be replaced with nickel.

Next, let us look at Figure and Table 2-2-2-3, and Figure 4-2 (in Chapter 4). Here we can see that in 2002, the Pd in North American autocatalyst was being replaced with Pt and other metals, and the consumption of Pd as a autocatalyst metal declined to about 1/3 of the previous year's level. This possibility was not mentioned during interviews with Japanese autocatalyst manufacturers. The reasons for this will be discussed later.

It should be noted that according to Figure 4-3 (in Chapter 4), the consumption of Pd (and other Pt group metals) in European automobiles started around 1992. This indicates that until about 1990 or so, automobile exhaust regulations in Europe were lagging behind elsewhere.

Incidentally, from 1985 to 2000, most of the demand for Pd in Japan was for electronics, electrical equipment and related fields. However, demand quickly started dropping in 2001 so that by 2003, demand was mainly for automobiles and dental Demand in the electronics fields has not recovered. This may be because of the complete switchover from Pd to Ni at MLCC (Multi-layered ceramic condensers). Therefore, it might be more expensive to

recycle waste electronic equipment containing poor Pd mounted circuit board after their product life ends in about 10 years.

Figure 2-2-2-1 World palladium supply by region

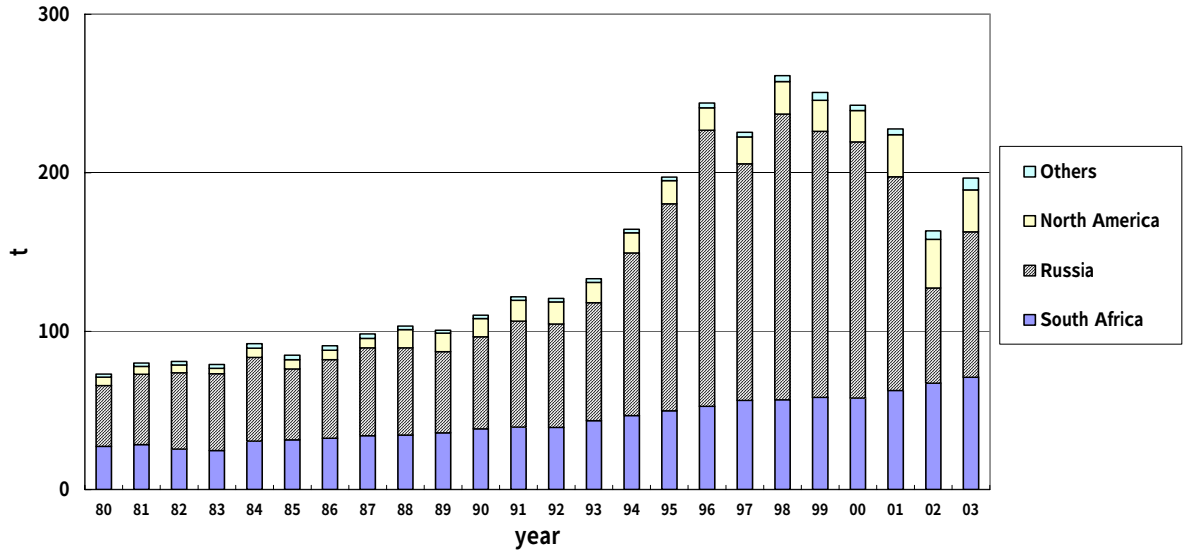


Figure 2-2-2-2 World palladium demand by market sector

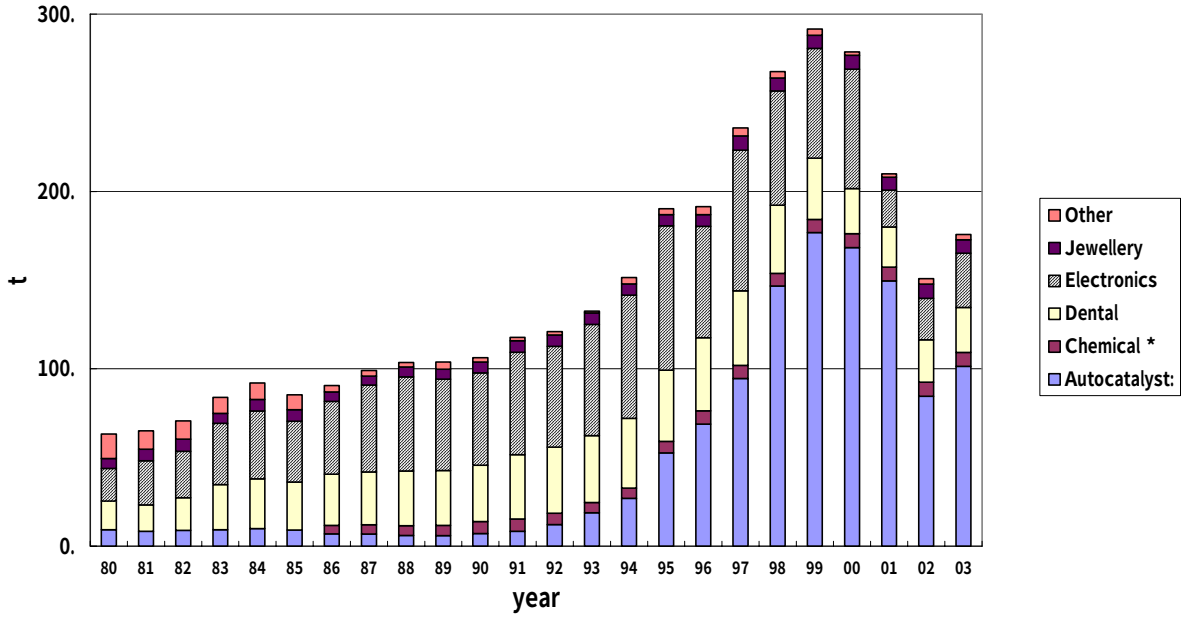


Figure 2-2-2-3 World palladium demand by region

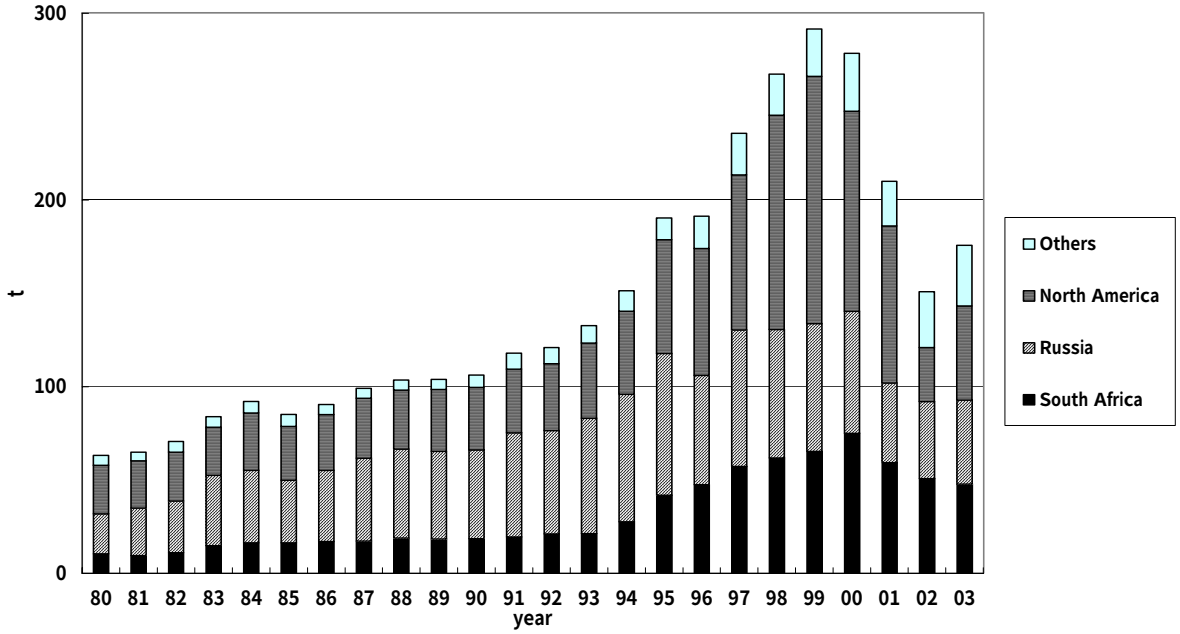


Figure 2-2-2-4 Palladium demand for the automobile industry by region

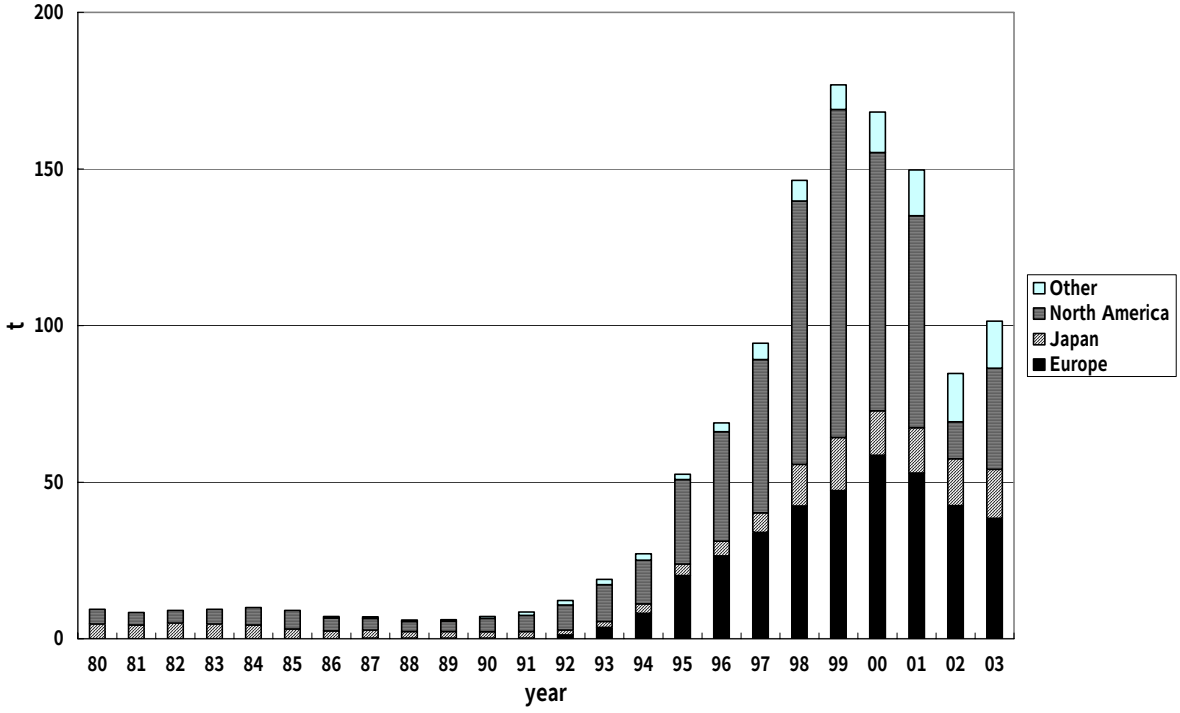
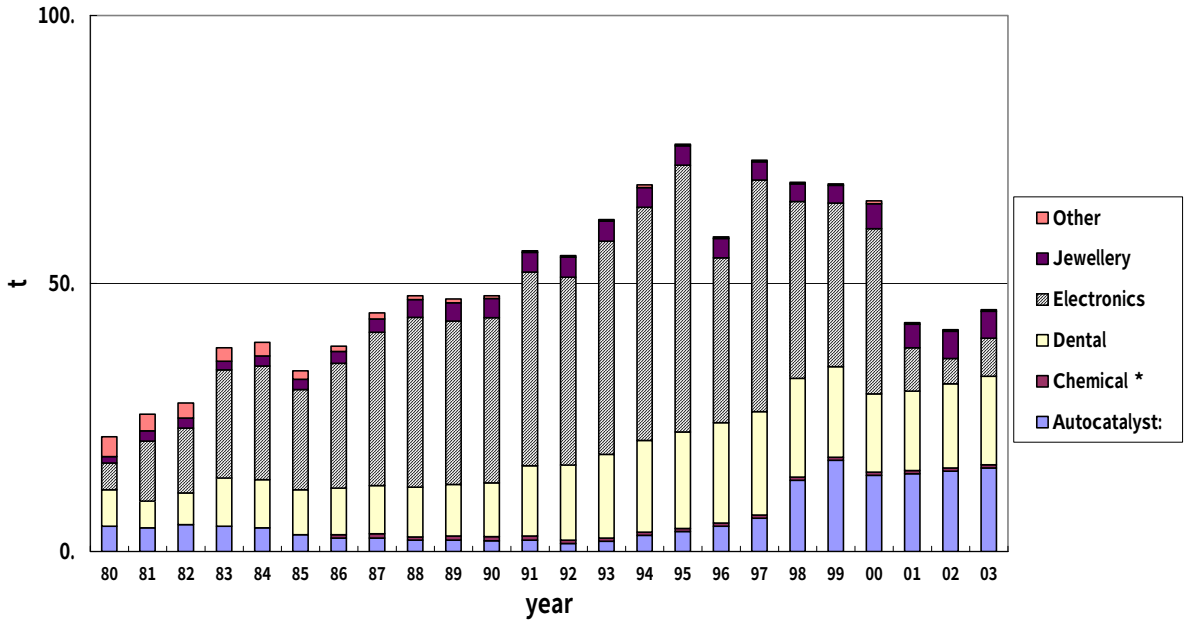


Figure 2-2-2-5 Japanese palladium demand by market sector



(3) Trends in the supply/demand and price fluctuations of rhodium

Figure and Table 2-2-3-2 show trends in world rhodium use. As we can easily see, use in automobiles accounted for 55% in 1985, but increased thereafter, reaching above 80% in the 1990s. Therefore, we can conclude that there are few other uses for rhodium. As mentioned in Section 2.1 (3), there has been a nearly 30 times as many as differential between highest and lowest prices since 1978, the largest price difference among the Pt group metals. This wild fluctuation occurs because there are none of other uses to provide a buffering effect for supply and demand.

As Figure 2-2-1 shows, the price of rhodium peaked at $171.93/gram in January 1991. Before 1990, the price was very low, but demand surged when the metal became widely

used in autocatalyst in North America, Japan, and Western Europe. This is the first time that autocatalyst accounted for more than 80% of all use. The surge in price was caused by such an increase in demand .

A second peak in price ($68.52/gram) occurred in February 2001, after the metal had started another rise in 2000. This was because of increased demand in all worldwide regions for rhodium as a component of autocatalyst in response to strengthened exhaust gas regulations in Western Europe, Japan and the United States. This was also to minimize the increase in palladium use that had emerged in 1999, and to reduce dependence on this Pd metal.

For example, the introduction of the EU 3 exhaust emission regulations implemented in January 2001 led to an increase in Rh consumption. The major Japanese automobile makers made a concerted effort to reduce Pd consumption, and achieved some of their goals. American automobile makers also employed a strategy of reducing Pd use.

Figure 2-2-3-1 World supply of rhodium by region

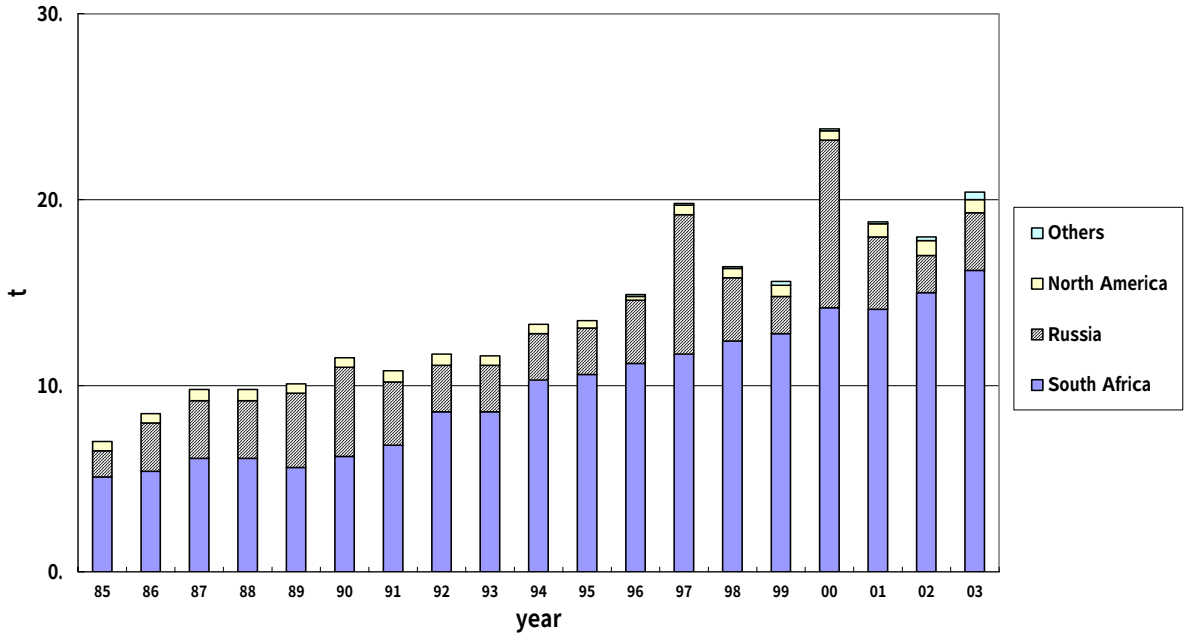


Figure 2-2-3-2 World demand of rhodium by market sector

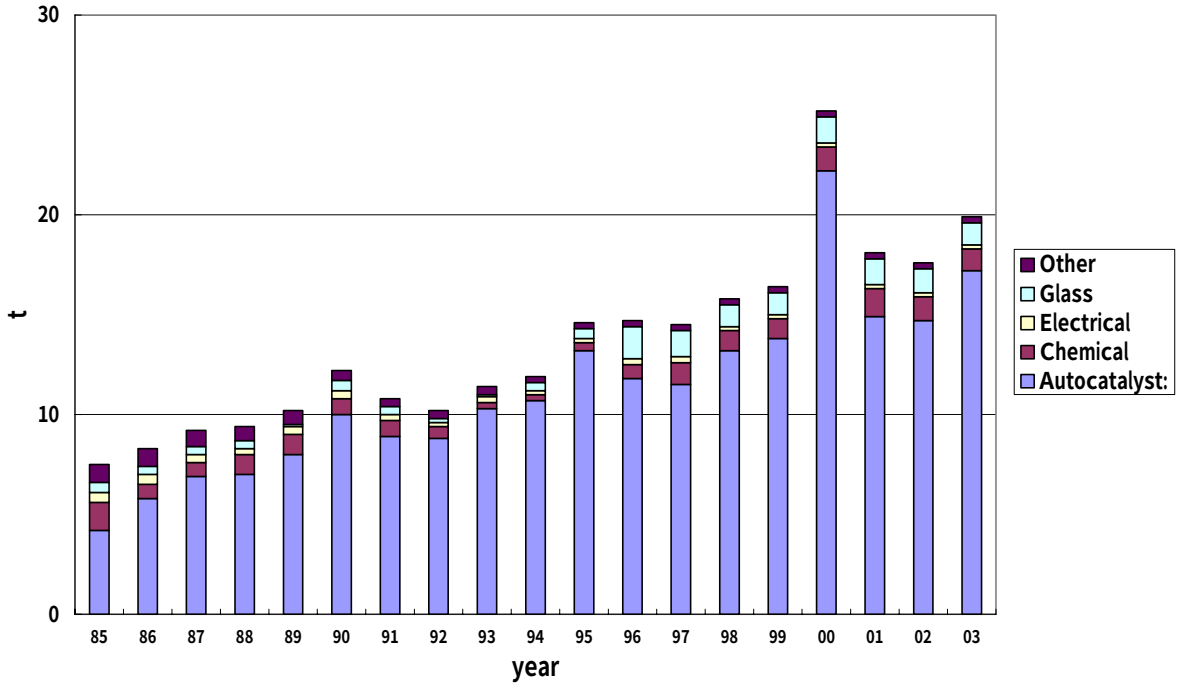
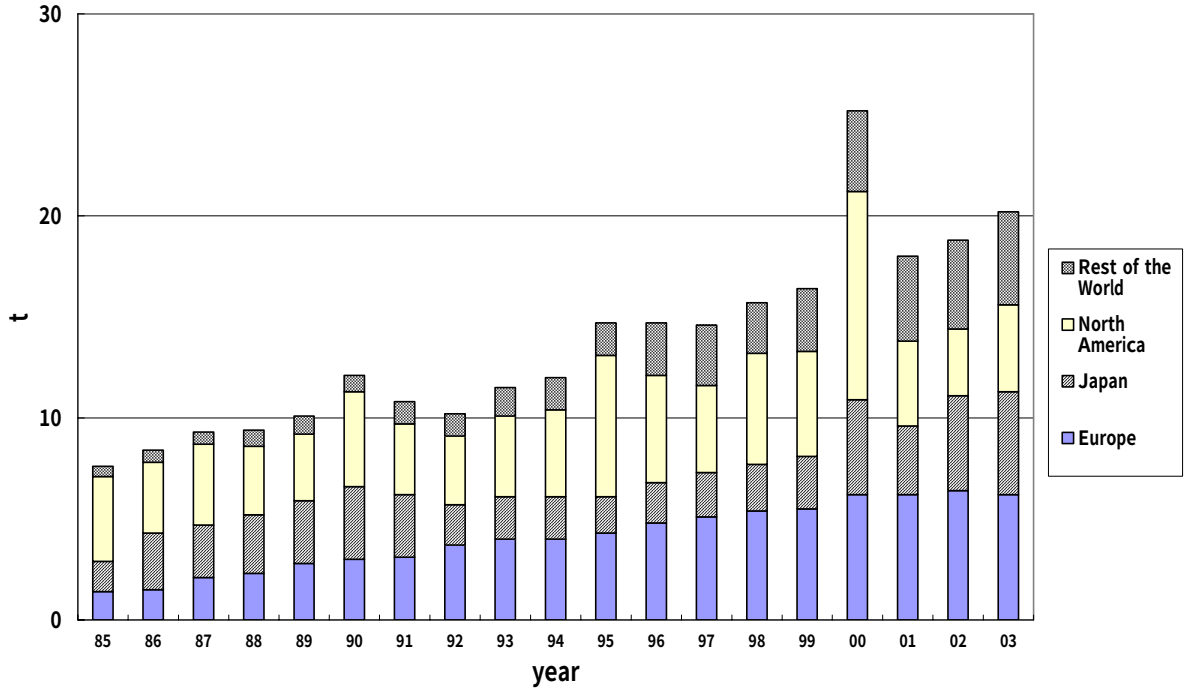


Figure 2-2-3-3 World demand of rhodium by region



3. Recycling Metals in Autocatalyst

3.1 Import of Pt group scrap

Table 3-1-1 gives a rundown of the amount of precious metal scrap that has been imported by Japan since 1994. According to Japan Exports & Imports statistics (Figure 3-1-1) for scrap imports (HS 7112.90.000), silver scrap (scrap metal with silver attached) was lumped other types of precious metal scrap beginning in 1996 together .

However, since there was none of distinction between silver and other precious metals, it had been difficult to estimate the amount of imported precious metal scrap from these statistics. However, in 2002 scrap was reclassified into gold, platinum, and silver, making it possible for the first time to estimate the amount of imported precious metal scrap.

The amount of metal recovered from imported precious metal scrap in Table 3-2-2 was derived by estimating the amount of autocatalyst produced 10 years ago based on an assumed automobile life span of 10 years. The results are shown in Tables 3-1-2 through 3-1-4. Furthermore, Table 3-1-1 shows that the dominant sources of silver scrap were South Korea, Hong Kong, Singapore and the United States, and this scrap was likely used in connectors for electronic and electrical parts. The United States accounts for the lion's share of Pt scrap imports, which probably come mostly from used autocatalyst. The amount of imported of silver/ precious metal scrap (HS7112-9) from the United States was roughly equal in 2001 and 2002, and the gross Pt scrap imports for 2001 were estimated to be the same as the 1,859,398 kg for 2002. The amount of Pt group metals

Table 3-1-1 Imports of silver and precious metal scrap (unit: kg)

year	HS number				Korea	Hong Kong	Singapore	United States	Total imports
1994	7112−90−000	silver scrap			-	87539	216019	242817	685257
1995	7112−90−000	silver scrap			1469	126415	207982	258455	764498
1996	7112−90−000	silver/precious metal scrap			275435	1256187	2618874	5377294	15125733
1997	7112−90−000	silver/precious metal scrap			3609047	1112175	2967760	5937871	18296905
1998	7112−90−000	silver/precious metal scrap			3826064	999363	3174250	5996768	17679525
1999	7112−90−000	silver/precious metal scrap			2841844	1621476	2103179	2646708	11692212
2000	7112−90−000	silver/precious metal scrap			975530	783510	2086540	3530482	10977147
2001	7112−90−000	silver/precious metal scrap			841615	223351	2498637	3619785	11012030
2002	7112-9	silver/precious metal scrap	(1)	(2)+(3)+(4)	659866	142099	2832088	3585037	11999739
	7112−91−000	gold scrap (*1)	(2)		3490	64	62390	-	355692
	7112−92−000	platinum scrap (*2)	(3)		97989	78	11108	1453171	1859398
	7112−99−000	silver scrap (*3)	(4)		558387	141957	2758590	2131866	9784649

*1) 7112-91-000: Gold scrap (including scrap metal with gold attached, excluding other precious metals)
*2) 7112-92-000: Platinum scrap (including scrap metal with platinum attached, excluding other precious metals)
*3) 7112-99-000: Silver scrap (including scrap metal with silver attached) other types of scrap used in the recovery of precious metals, and scrap containing precious metals or their alloys)

recovered from scrap were calculated from the values in Table 3-1-4 for US (North American) autocatalyst and the weight ratios of precious metals (estimated from the weight ratios of Japanese autocatalyst and precious metals), as follows:

Pt_1,859,398kg_0.183÷100 = 3.403 t

Pd_1,859,398kg_0.057÷100 = 1.060 t

Rh_1,859,398kg_0.041÷100 = 0.744 t.

Table 3-1-2 The unit weights of catalyst metals used in Japanese vehicle (demand/no. of vehicles produced) [Unit: g/vehicle]

	89	90	91	92	avearage1		average2	
	(1)	(2)	(3)	(4)	(1)-(3)average	100%	(2)-(4)average	100%
Pt	0.978	0.838	0.808	0.76	0.875	74.8%	0.802	71.1%
Pd	0.161	0.148	0.151	0.128	0.153	13.1%	0.142	12.6%
Rh	0.193	0.219	0.093	0.138	0.168	14.4%	0.150	13.3%
Total	1.152	1.205	1.152	1.026	1,170		1.128	

Table 3-1-3 The unit weights of catalyst metals used in North American vehicles (demand/no. of vehicles produced) [Unit: g/vehicle]

	89	90	91	92	average1		average2		average3
	(1)	(2)	(3)	(4)	(1)-(3)average	100%	(2)-(4)average	100%	
Pt	1.336	1.400	1.170	0.865	1.302	69.2%	1.145	61.1%	65.1%
Pd	0.238	0.334	0.378	0.624	0.317	16.8%	0.445	23.9%	20.3%
Rh	0.201	0.329	0.270	0.251	0.268	14.2%	0.283	15.1%	14.7%
Total	1.775	2.063	1.817	1.741	1.885		1.874		

Table 3-1-4 The unit weights of North American Pt group metals estimated from the unit weight of Pt group metals used in Japanese autocatalyst [Unit: tons]

	Japan								Unite State			
	Prod. of catalyst gross(t)	Prod. of catalyst metal(t)			Ratio of metal to gross(100%)				Ratio of metal to gross(100%)			
	(1)	(2)			(3)				(4)∗1)			
					(2)/(1)							
		Pt	Pd	Rh	Pt	Pd	Rh	Total	Pt	Pd	Rh	Total
1990	5,677	12.4	5.14	3.24	0.22	0.09	0.06					
1991	5,248	11.8	5.80	2.79	0.22	0.11	0.05					
1992	4,907	10.9	4.86	1.80	0.22	0.10	0.04					
ave.					0.222	0.100	0.049	0.371	0.20	0.14	0.04	0.371

*1) is the Japanese value column(3) (0.283) in Table 3-1-4 converted into the American value in column(4) of 0.2808. This value was then divided proportionally by the average value of “average 3” in Table 3-1-3.

3.2 Recovery of Pt group metals from the vehicles discarded in Japan

The following catalyst unit weights of Japan producing vehicles were derived from Table 3-1-2 and used to estimate the amount of Pt group metals recovered in Japan from the vehicles discarded.

(a) Platinum Unit weights of vehicles in 2001

Assuming an average life span of 10 years for an vehicles, the per vehicle amount of platinum from used autocatalyst (unit weights) was derived from the averages of three years (1990, 91, 92) in Table 3-1-2 and listed in Table 2-1-2 as column “average 2”

Pt→0.802g, Pd→0.0.142g, Rh→0.150g

(b) Recovery of Pt in 2001

The data indicate that in 2001 in Japan, 5,147,808 cars were taken off the road, of which 1,000,000 or so were exported as used cars. Therefore, approximately 4,150,000 vehicles had to be discarded of.

Assuming that all the used autocatalyst were recovered, we get

Pt→4,150,000×0.802 g÷1000000 = 3.328 t

Pd→4,150,000×0.142 g÷1000000 = 0.587 t

Rh→4,150,000×0.150 g÷1000000 = 0.623 t

(c) Platinum unite weights of vehicles in 2000

The unite weights was derived from the averages of three years (1989 90, 91) in Table 3-1-2. As we can see in Table 3-1-2, average values are as follows:

Pt→0.875g, Pd→0.153g, Rh→0.168g

(d) Recovery of platinum in 2000

Assuming that 5,036,705 vehicles were taken off the road in Japan in 2000, and 4,036,705 of these vehicles had to be discarded of in the country, then

Pt→4,036,705×0.875 g÷1000000 = 3,532 t

Pd→4,036,705×0.153 g÷1000000 = 0.618 t

Rh→4,036,705×0.168 g÷1000000 = 0.678 t

3.3 Comparison with the recovery figures of the Used Catalyst Recycling Association

(1) Estimates based on assumptions

Table 3-3-1 Comparison between the recovery figures of the used catalyst by Used Catalyst Recycling Association, imported scrap, and recovery from domestic discarded vehicles

	2000				2001			
	UCRA recovery	Imported scrap	Discarded vehicle recovery	Subtotal	UCRA recovery	Imported scrap	Used vehicle recovery	Subtotal
	‘(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
				(2)+(4)				(6)+(7)
Pt	4.2t	3.403t	3.532t	6.935t	4.8t	3.403t	3.328t	6.731t
Pd	12.5t	1.060t	0.618t	1.678t	13.9t	1.060t	0.589t	1.648t
Rh	0.810t	0.744t	0.678t	1.422t	0.887t	0.744t	0.623t	1.367t

If adding "imported scrap" in Table 3-1-1 to the amount recovered from discarded vehicle listed above, then the values derived here are much higher than the values reported by the

Used Autocatalyst Recycling Association.

(2) Estimates based on interviews with dismantler-auto machine parts recycler

The concepts described here were discussed by telephone with four salvage companies in the Kanto (2 in Saitama, 1 in Tochigi) and Kansai (1 in Osaka) regions. As a result,

(1) More than 50% of recently scrapped autocatalyst consist of two types: the first is double catalyst type. That is a smaller one autocatalyst, which are attached near the manifold, and a larger one, which are attached to the muffler on the outside. The second is only one attached the muffler type, is quite old type and decreasing in number.

The larger one is about 2 times as large as the smaller one. Recently, however, the larger one have been getting smaller.

(2) The above smaller one attached near the manifold require much effort for disassembly, so the recovery rate is only about 50%. In contrast, the muffler-attached autocatalyst are easy to remove and nearly all of them are recovered.

(3) Used autocatalyst that are imported have had their fittings (stainless steel cases which are separately recycled) removed in Asia and the United States. Such used autocatalyst are usually shipped (imported) in flexible containers.

(4) About 30% of the used autocatalyst (with fittings) collected in Japan are not disassembled there because of high labor costs; rather, they are exported to other Asian

countries or the United States for disassembly. After disassembly, they are returned to Japan.

Given the above findings, if we assume a larger one to a smaller one ratio of 2:1, consider the proportions of size and weight to be equal, and assign a value of 1 to the total emission of used autocatalyst, then

(1) × (1/3) × (1/2) ＝ 1/6 ＝ A

↓

[Total discard] × [proportion of smaller catalyst weight to total weight] × [recovery rate of smaller catalyst] ＝ [rate of unrecovered smaller catalyst]

(1) × (1・A) × (1/3) = (1) × (5/6) × (1/3) ＝ 5/18 ＝ B

↓

[Total discard] × [domestic recovery amount] × [30% of exported catalysts from domestically recovered units] ＝ [export from domestically recovered units]

A+B＝8/18

↓

[This is the amount of domestically used autocatalyst that are not recycled.]

About 50% of this 8/18 will not be recycled in Japan. Therefore, only about 50% of the units are recovered in the country. This information was used to correct the data in Table 3-3-1, which appears in Table 3-3-2. Because fitting is not attached to the catalytic metals that are imported into Japan, the amount of imported precious metals is not less than trade statistics value. In other words, the present recovery value is higher than that reported by the Used Autocatalyst Recycling Association. Perhaps there are gaps in the UCRA data (some nonferrous smelting companies are not members of the UCRA), and maybe there are some

errors with the estimates used in the present report.

Table 3-3-2 Comparison between recovery rates of the present study and the Used Autocatalyst Recycling Association

	2000				2001			
	UCRA recovery rate	Imported scrap (Est.)	Discarded vehicle recovery	Subtotal (Est.)	UCRA recovery rate	Imported scrap (Est.)	Discarded vehicle recovery (Est.)	Subtotal (Est.)
	‘(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
				(2)+(4)				(6)+(7)
Pt	4.2t	3.403t	1.676t	5.079t	4.8t	3.403t	1.664t	5.067t
Pd	12.5t	1.060t	0.309t	1.369t	13.9t	1.060t	0.295t	1.355t
Rh	0.810t	0.744t	0.339t	1.083t	0.887t	0.744t	0.312t	1.056t

Note: Values for columns (3) and (7) in Table 3-3-2 are half of the values for the respective columns in Table 3-3-1.

Incidentally, most of the Pt and Rh catalytic metals are recovered from automobile autocatalyst, while the vast majority of Pd is recovered from other types of chemical catalytic media. A comparison of UCRA and estimated values shows the estimated value of Rh are slightly higher than that of Pt. Between muffler sections and manifold section, there should be differences in contents of Rh and Pt , and there are also differences between the used precious metal components and the recovered components.

4. Comparison of autocatalyst unite weights by region

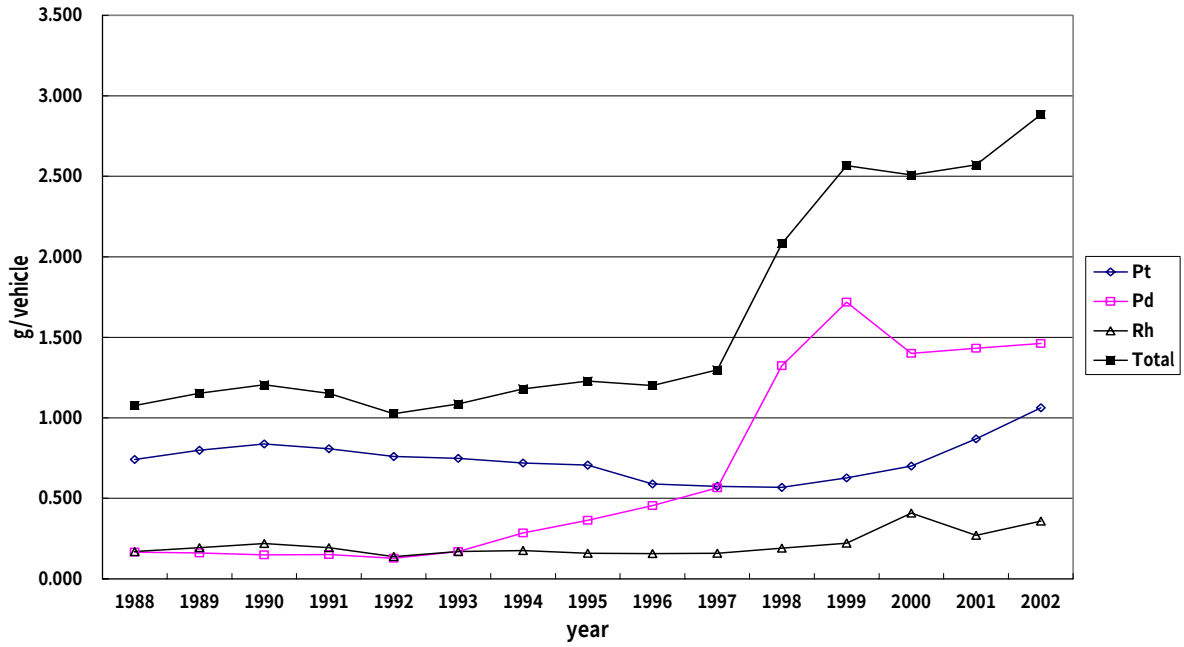
4.1 Japan

Figure and Table 4-1 show trends in Pt group metal unit weights of autocatalyst in Japan. These figures represent the amount of catalytic materials consumption for automobiles (as per Johnson Matthey data) divided by the number of automobiles produced (as per the Japan Automobile Manufacturer Association data). Until 1996, the amount of precious metal consumed per vehicle in Japan was about 1.00-1.3g, but in 1997 it exceeded

2.0g/vehicle and has continued to rise, reaching 2.88g/vehicle in 2002, or nearly 3 times the original level. This increased consumption is due to strengthened exhaust gas regulations. It should be noted that Pd and Rh consumption had declined a bit from the peak, but it is currently back on the rise. For its part, Pt use has been steadily increasing.

One of the reasons for this increase in Pt use may be the effect of particulate matters (unburned hydrocarbons) regulations for diesel vehicles that went into effect in the Tokyo Metropolis in October 2003. Platinum is the most effective catalyst known for suppressing particulate emissions. In addition, the national government implemented new NOx and particulate regulations for diesel vehicles in the same month, but they do not necessarily mandate the installation of equipment, and their effect will not appear until 2005. In other words, Japanese government regulations mean that consumption of Pt will continue to rise.

Figure 4-1 Autocatalyst unit weights in Japan (amount of catalyst metals/number of vehicle) [Unit: g/vehicle]



4.2 North America

As we can see in Figure and Table 4-2, the amount of precious metal used per vehicle in North America until 1993 was about 2 grams, or about twice that of Japan. This is natural considering that the engine displacement of vehicles in North America is also about twice as high as Japan. At any rate, the consumption of precious metals began to increase in 1994, reaching a level of 7.08-7.09g/vehicle in 1998-99. However, it quickly declined after that , falling back to 2.73g/vehicle in 2002, about the same level as Japan. Because North American vehicles have a much greater engine displacement overall than Japanese vehicles, this is a revolutionary event.

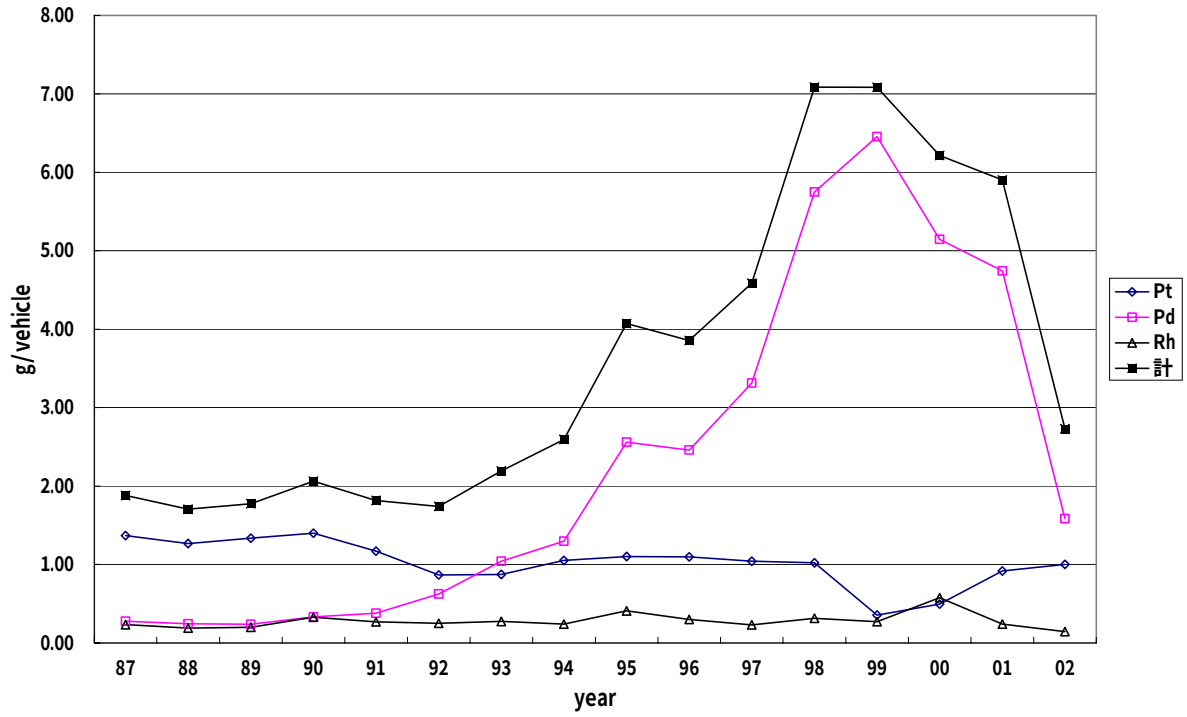
According to sources from the American Autocatalyst Manufacturer's Association, the average amount of precious metals used in North American vehicles did, indeed, rise to 5.90-7.09g between 1999 and 2001. This marked the start of the large amounts of Pd which was still cheap at the development stage. At one time in North America, it went without saying that one vehicle would have five catalytic units.

However, the number of units has since been reduced from 5 to 3, and plans are proceeding to reduce the amount of metal in the autocatalyst. Due to the rapid increase in the price of Pd, even among the Pt group, the metal is becoming harder to use as in sutocatalyst. Thus, there is a transition back to Pt and Rh, and the catalyst series is being reviewed to provide a better balance in Pt group metals. At the same time, major advances in engine control systems have vastly improved the light-off performance of catalysts (that is, lower operating temperatures increase performance).

The technology developed in North America is also being developed in Western Europe and Japan, and it is expected that advances will be reflected in decreases in Pt group

consumption about one or two years later. However, as was shown in two chapters ago in Table 2-2-2-4, Pd use in European automobiles declined from 43 t to 39 t from 2002-2003, but it increased from 12 t to 32 t during the same period in the United States. However, this does not reflect an actual increase in demand in the United States (since actual consumption is declining), but rather a stocking of the metal by automobile makers.[1)] Only Japan showed a real increase, from 15 t to 16 t. This may be because of the special conditions in Japan, where small cars are the norm.

Figure 4-2 Autocatalyst metal unit weights in North America (amout of catalytic metals/number of vehicle) [Unit: g/vehicle]



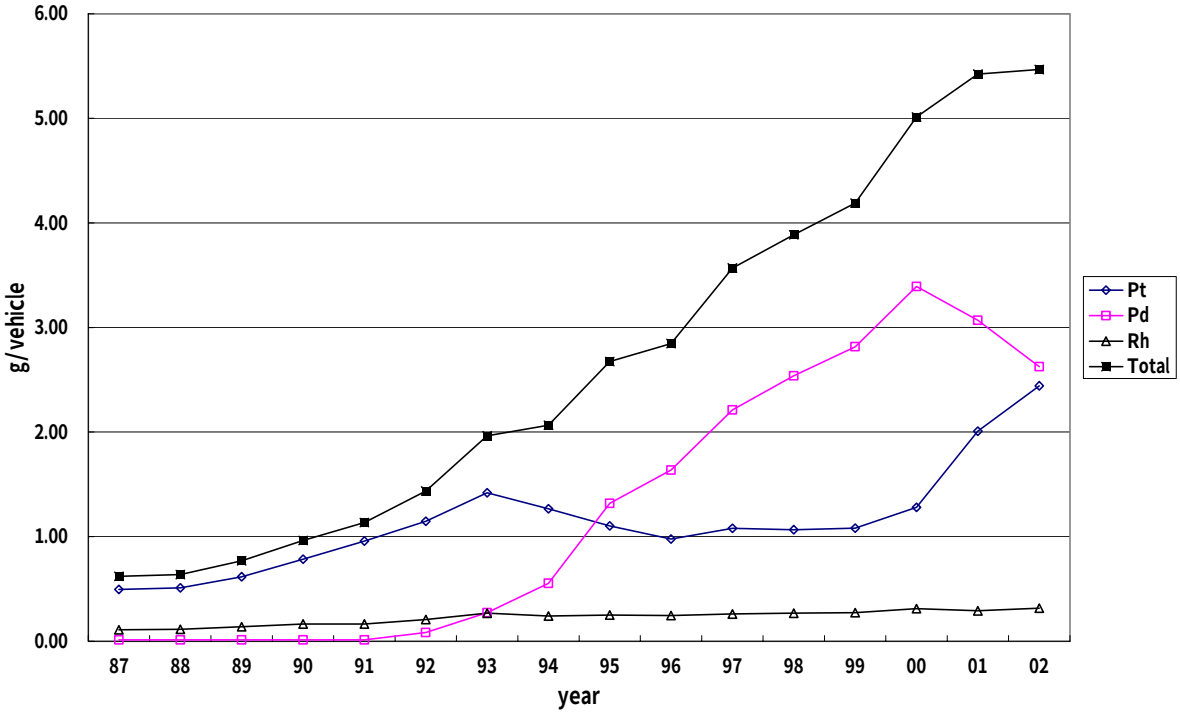
4.3 Western Europe

As we can see in Figure and Table 4-3, the amount of precious metal used per vehicle in Western Europe until 1990 was not quite 1 gram, a little lower even than the per vehicle rate in Japan of 1 gram. However, starting around 1991, there was explosive growth in precious

metal use, reaching 5.42 g/vehicle in 2001. It increased only slightly, to 5.47 g/vehicle, in 2002, and stayed at the same level in 2003.

At the present time, more precious metal is used per vehicle in Western Europe than in the United States or Japan. The reason for this is that, despite the reduction in Pd consumption since 2001, the increased use of Pt has compensated for this reduction. That is because demand for diesel vehicles (which use more Pt in their autocatalyst) in Europe has been increasing, and the European IV standards which are scheduled for implementation in 2005 have already been applied to new 2003 vehicles, that is, manufacturers are already making vehicles that can pass the new standards.

Figure 4-2 Autocatalyst metal unit weights in Western Europe (amount of catalytic metals/number of vehicle) [Unit: g/vehicle]



Reference

1) Interim review of Platinum2003,JM[Johnson Matthey];

DATA

Table 2-2-1-1 World Platinum Supply (unit : t)

	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	00	01	02	03
South Africa	55	53	55	61	68	72	56	61	64	71	73	73	78	80	82	86	86	86	105	98	105	105	115	115	121	118	128	138	145
Russia	19	22	20	15	14	11	12	12	9	8	7	9	12	14	17	22	34	23	21	31	40	38	28	40	17	34	40	30	30
North Ameri	4	5	5	5	4	4	4	4	3	5	5	5	4	7	6	6	7	6	7	7	8	8	8	9	8	9	11	11	9
Others	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2	2	4	4	4	3	4	4	4	5	3	3	4	7
Totals	79	81	81	82	87	88	73	77	77	85	86	88	96	102	107	116	129	119	137	141	155	155	154	168	152	165	182	183	190

Table 2-2-1-2 World Platinum Demand by Market Sector (unit : t)

	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	00	01	02	03
Autocatalys	11	15	14	20	28	21	20	20	19	25	28	33	35	36	40	41	42	41	45	49	48	48	45	43	37	44	62	61	79
Chemical	11	8.7	12	11	11	8.1	7.8	8.1	7.6	8.1	7	6.1	6.1	5	5.1	6.7	7.5	6.7	5.6	5.9	6.7	7.2	7.3	8.7	10	9.2	9	9.3	10
Electrical	7	7.5	8.7	6.2	7.5	6.5	5.8	5.3	5.4	5.9	6.2	5.6	5.6	5.8	6.1	6.4	5.4	5.1	5.1	5.8	7.5	8.6	9.5	9.3	12	14	12	12	12
Glass	2	3	3.4	5.9	7.8	4.4	3.1	2.6	3.3	4.4	4.4	2.8	3.7	4	4.4	4.2	3.7	2.5	2.5	5	7	7.9	8.2	6.8	6.2	7.9	8.9	8.1	7.6
Investment						5	6.1	5	4.8	10	13	10	15	20	4.9	6.2	13	7.9	9.5	12	11	7.4	7.5	9.8	5.7	-2	2.8	2.8	0.3
Jewellery	38	30	33	31	24	17	24	24	22	24	25	26	31	37	40	43	46	47	50	54	56	62	67	76	90	88	81	87	76
Petroleum	5.1	2.8	3.7	5.3	5	4	4.4	2	0.6	0.5	0.5	0.6	1.7	1.6	2.3	4.4	4.7	3.7	3.3	2.8	3.7	5.8	5.3	3.9	3.6	3.4	4	4.2	4
Other	6.5	7.9	7.9	5.8	5.9	5.9	5.1	5.3	4.7	4.2	3.1	4	3.7	3.7	3.6	3.7	4.4	4.7	5.1	5.9	7	7.9	9.2	9.5	10	12	15	15	16
Totals	81	76	84	88	90	73	77	73	68	83	89	90	103	114	108	115	126	119	126	143	151	154	160	167	174	177	194	198	205

Table 2-2-1-3 World Platinum Demand by Region (unit : t)

	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	00	01	02	03
Europe	10	12	16	12	13	9	13	10	10	12	12	15	17	17	19	22	24	27	28	29	27	26	27	28	31	36	47	52	57
Japan	43	36	34	36	29	29	36	33	30	36	39	31	51	59	52	58	64	58	61	67	69	62	59	56	57	44	41	43	41
North Ameri	22	23	25	30	42	31	22	22	22	28	31	37	28	27	28	25	25	22	24	29	32	37	39	41	34	38	40	31	42
Others	5.6	4.4	7.5	5.3	5	3.7	5	7.2	5.6	5.6	5.3	5.3	5.6	9.3	8.2	11	13	12	13	16	19	29	35	42	53	59	66	73	65
Totals	80	75	82	84	89	73	76	72	68	82	88	88	102	112	107	115	127	119	126	141	147								
West→Chin	0.6	0.9	1.6	3.7	0.9	0.9	0.9	0.9	0.6	0.9	0.9	1.2	0.9	1.2	1.2	0	-1	0	0.6	1.6	4								
Totals	81	76	84	88	90	73	77	73	68	83	89	90	103	114	108	115	126	119	126	143	151	154	160	167	174	177	194	198	205

Table 2-2-1-4 World of other region Platinum Demand by Market Sector (unit : t)

	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	00	01	02	03
Autocatalyst:								0	0	0	0.2	0.6	0.9	1.6	1.9	2.2	2.6	3.1	4.8	5.6	6	8.2	8	7.2	7.7	8.7	9	11	12
Chemical								1.9	1.4	1.2	1.2	1.2	1.4	1.2	1.4	2.5	2	1.7	1.6	1.9	2.2	2.2	2	3.7	3.9	2.3	1.9	2.5	2.6
Electrical								0.6	0.6	0.6	0.8	0.9	0.9	1.1	0.9	1.1	0.9	0.9	1.1	1.2	1.7	2.3	3	3	3.3	4.4	3.7	3.7	3.7
Glass								0.2	0.3	0.3	0.3	0.2	0.6	0.9	1.1	1.1	1.4	0.9	0.6	0.9	1.9	3.3	3.6	3	2.8	3.7	5	4.2	3.7
Investment								0	0	0.2	0.2	0.5	0.2	2.3	0.3	0.5	0.9	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0	0	0
Jewellery								2.8	3	2.8	2.2	1.2	0.9	1.1	1.7	2.3	3.3	3.1	3.6	4.2	4.5	9.2	14	22	33	37	43	49	40
Petroleum								1.2	0	0.2	0.3	0.5	0.5	0.9	0.8	1.4	1.7	1.7	0.9	1.7	1.9	3.3	3.1	2	1.7	1.7	2.2	2.2	2
Other								0.5	0.3	0.3	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.3	0.5	0.6	0.6	0.6	0.8	0.8	0.8	0.9
Totals								7.2	5.6	5.6	5.3	5.3	5.6	9.3	8.2	11	13	12	13	16	19	29	35	42	53	59	66	73	65

Table 2-2-1-5 Japanese Platinum Demand by Market Sector (unit : t)

	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	00	01	02	03
Autocatalys	1.9	1.9	2.5	5.6	6.2	6.5	5.9	5.3	5.3	5.3	6.5	7.7	9.1	9.5	10	11	11	9.5	8.4	7.6	7.2	6	6.3	5.8	5.9	7.1	8.9	11	13
Chemical	0.9	0.6	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.5	0.5	0.5	0.5	0.5	0.5	0.8	0.6	0.6	0.5	0.5	0.6	0.6	0.6	0.6	0.6	0.6	0.8	0.9	0.9
Electrical	1.6	0.9	0.5	0.5	0.5	0.5	0.5	0.6	0.6	0.9	1.2	1.4	1.4	1.4	1.6	1.6	1.6	1.6	1.4	1.4	1.4	1.4	2	1.7	2.3	2.8	2.5	2.5	2.5
Glass	1.6	1.2	0.9	1.2	1.2	1.2	1.6	1.4	1.9	2.3	1.9	0.9	1.4	1.4	1.2	1.6	1.1	0.6	0.9	2.5	3.3	2.5	2.6	2.5	2	2	2.6	2.5	2.3
Investment						5	6.1	3.6	2.2	5.2	6.4	-3	11	13	2	4.3	9.5	4.6	7.3	8.7	9.5	4.8	2.7	4.1	3.4	-3	1.4	1.4	-0
Jewellery	33	26	26	26	18	14	19	19	17	19	21	23	28	33	36	37	39	40	42	45	46	46	43	40	41	33	23	23	21
Petroleum	1.2	1.1	0.6	0.5	0.3	0.5	0.5	0.5	0.5	0.6	0.5	0	0	0	0	0.5	0.5	0.3	0.3	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Other	2.8	3.9	3.3	2.3	1.7	1.6	1.6	1.7	1.4	1.2	0.9	0.6	0.5	0.5	0.5	0.5	0.6	0.8	0.6	0.8	0.8	0.8	0.9	0.9	1.1	1.1	1.1	1.2	1.2
Totals	43	36	34	36	29	29	36	33	30	36	39	31	51	59	52	58	64	58	61	67	69	62	59	56	57	44	41	43	41

Table 2-2-1-1 World Palladium Supply (unit : t)

	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	00	01	02	03
South Africa	27	28	26	25	31	31	32	34	34	36	38	40	39	43	47	50	53	56	57	58	58	63	67	71
Russia	39	45	48	49	53	45	50	56	55	51	58	67	65	75	103	131	174	149	180	168	162	135	60	92
North Americ	5	5	5	3	6	6	6	6	12	12	12	13	14	13	13	15	14	17	21	20	20	27	31	26
Others	2	2	2	3	3	3	3	3	2	2	2	2	2	2	2	2	3	3	4	5	3	4	5	8
Total	73	80	81	79	92	85	91	98	103	101	110	122	121	133	164	197	244	226	261	251	243	228	163	197

Table 2-2-1-2 World Palladium Demand by Market Sector (unit : t)

	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	00	01	02	03
Autocatalyst	9	8	9	9	10	9	7	7	6	6	7	8	12	19	27	53	69	95	147	177	168	150	85	101
Chemical							5	5	5	6	7	7	6	6	6	7	8	8	7	7	8	8	8	8
Dental	16	15	18	26	28	27	29	30	31	31	32	36	37	38	39	40	41	42	38	35	26	23	24	25
Electronics	18	25	26	35	38	34	41	49	53	52	52	58	57	63	69	82	63	79	65	62	67	21	23	31
Jewellery	6	7	7	6	7	7	5	5	6	6	6	7	6	7	6	6	7	8	7	7	8	7	8	8
Other	14	10	10	9	9	8	4	3	3	4	3	2	2	1	4	3	4	4	4	4	2	2	3	3
Total	63	65	71	84	92	85	91	99	104	104	106	118	121	133	152	190	191	236	268	292	279	210	151	176

Table 2-2-1-3 World Palladium Demand by Other Region (unit : t)

	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	00	01	02	03
South Africa	10	9.3	11	15	16	16	17	17	19	18	18	19	21	21	28	42	47	57	62	65	75	59	51	48
Japan	22	26	28	38	39	34	38	45	48	47	48	56	55	62	68	76	59	73	69	69	65	43	41	45
North Americ	26	26	26	26	31	29	30	32	32	33	34	34	36	40	45	61	68	83	115	132	107	84	29	51
Others	5.3	4.7	5.6	5.6	6	6.5	5.4	5.3	5.4	5.3	6.7	8.6	8.7	9.3	11	12	17	22	22	25	31	24	30	32
Total	63	65	71	84	92	85	91	99	104	104	106	118	121	133	152	190	191	236	268	292	279	210	151	176

Table 2-2-1-4 World Palladium Demand for the vehicle by Market Sector (unit : t)

	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	00	01	02	03
Europe	0	0	0	0	0	0	0	0	0	0	0	0	1	4	8	20	27	34	42	47	59	53	43	39
Japan	5	4	5	5	4	3	3	3	2	2	2	2	2	2	3	4	5	6	13	17	14	15	15	16
North Ameri	5	4	4	5	6	6	4	4	3	3	4	5	8	12	14	27	35	49	84	105	83	68	12	32
Other							1	1	1	1	1	1	1	2	2	2	3	5	7	8	13	15	15	15
Totals	9	8	9	9	10	9	7	7	6	6	7	8	12	19	27	53	69	95	147	177	168	150	85	101

Table 2-2-1-5 Palladium Demand by Market Sector in Japan(unit : t)

	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	00	01	02	03
Autocatalyst:	5	4	5	5	4	3	3	3	2	2	2	2	2	2	3	4	5	6	13	17	14	15	15	16
Chemical							1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Dental	7	5	6	9	9	8	9	9	9	10	10	13	14	16	17	18	19	19	18	17	15	15	16	17
Electronics	5	11	12	20	21	19	23	29	32	31	31	36	35	40	44	50	31	43	33	31	31	8	5	7
Jewellery	1	2	2	2	2	2	2	3	3	3	4	4	4	4	4	4	4	3	3	3	5	4	5	5
Other	4	3	3	3	3	2	1	1	1	1	1	0	0	0	1	0	0	0	0	0	1	0	0	0
Totals	22	26	28	38	39	34	38	45	48	47	48	56	55	62	68	76	59	73	69	69	65	43	41	45

Table 2-2-1-1 World Rhodium Supply (unit : t)

	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	00	01	02	03
South Africa	5.1	5.4	6.1	6.1	5.6	6.2	6.8	8.6	8.6	10.3	10.6	11.2	11.7	12.4	12.8	14.2	14.1	15.0	16.2
Russia	1.4	2.6	3.1	3.1	4.0	4.8	3.4	2.5	2.5	2.5	2.5	3.4	7.5	3.4	2.0	9.0	3.9	2.0	3.1
North America	0.5	0.5	0.6	0.6	0.5	0.5	0.6	0.6	0.5	0.5	0.4	0.2	0.5	0.5	0.6	0.5	0.7	0.8	0.7
Others	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.2	0.1	0.1	0.2	0.4
Totals	**7.0**	**8.6**	**9.7**	**9.9**	**10.1**	**11.5**	**10.8**	**11.8**	**11.7**	**13.3**	**13.6**	**14.8**	**19.8**	**16.5**	**15.6**	**23.8**	**18.8**	**18.0**	**20.4**

Table 2-2-1-2 World Rhodium Demand by Market Sector (unit : t)

	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	00	01	02	03
Autocatalyst:	4.2	5.8	6.9	7.0	8.0	10.0	8.9	8.8	10.3	10.7	13.2	11.8	11.5	13.2	13.8	22.2	14.9	14.7	17.2
Chemical	1.4	0.7	0.7	1.0	1.0	0.8	0.8	0.6	0.3	0.3	0.4	0.7	1.1	1.0	1.0	1.2	1.4	1.2	1.1
Electrical	0.5	0.5	0.4	0.3	0.4	0.4	0.3	0.2	0.3	0.2	0.2	0.3	0.3	0.2	0.2	0.2	0.2	0.2	0.2
Glass	0.5	0.4	0.4	0.4	0.1	0.5	0.4	0.2	0.1	0.4	0.5	1.6	1.3	1.1	1.1	1.3	1.3	1.2	1.1
Other	0.9	0.9	0.8	0.7	0.7	0.5	0.4	0.4	0.4	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
Totals	**7.6**	**8.3**	**9.2**	**9.5**	**10.2**	**12.2**	**10.8**	**10.2**	**11.4**	**12.1**	**14.7**	**14.6**	**14.5**	**15.8**	**16.4**	**25.2**	**18.1**	**17.6**	**19.9**

Table 2-2-1-3 World Rhodium Demand by Region (unit : t)

	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	00	01	02	03
Europe	1.4	1.5	2.1	2.3	2.8	3.0	3.1	3.7	4.0	4.0	4.3	4.8	5.1	5.4	5.5	6.2	6.2	6.4	6.2
Japan	1.5	2.8	2.6	2.9	3.1	3.6	3.1	2.0	2.1	2.1	1.8	2.0	2.2	2.3	2.6	4.7	3.4	4.7	5.1
North America	4.2	3.5	4.0	3.4	3.3	4.7	3.5	3.4	4.0	4.3	7.0	5.3	4.3	5.5	5.2	10.3	4.2	3.3	4.3
Rest of the Wo	0.5	0.6	0.6	0.8	0.9	0.8	1.1	1.1	1.4	1.6	1.6	2.6	3.0	2.5	3.1	4.0	4.2	4.4	4.6
Total	**7.6**	**8.3**	**9.2**	**9.5**	**10.2**	**12.2**	**10.8**	**10.2**	**11.4**	**12.1**	**14.7**	**14.6**	**14.5**	**15.8**	**16.4**	**25.2**	**18.0**	**18.8**	**20.2**

source :Platinum ,Johnson Matthey

note 1 :Before 1980, Investment demand is included in our Other estimates.

Note 2 :Before 1993, estimates include Eastern Europe; for 1993 and subsequent years ,demand in this region is included in our European figures.

Note 3 :From 1996, demand in China is incorporated in our Rest of the World estimates.

Note 4 :Totals may not add due to rounding