

Platinum-Group Metals

By J. Roger Loebenstein¹

The Stillwater Mining Co. (SMC) opened a new platinum-palladium mine in Montana and shipped its first concentrate to Belgium for refining. This was the first time since 1976 that the United States mined

platinum-group metals (PGM) as a primary product from a domestic deposit. The Republic of South Africa remained the leading producer of platinum. The U.S.S.R. remained the leading producer of palladium.

Table 1.—Salient platinum-group metals¹ statistics

(Thousand troy ounces unless otherwise specified)

	1983	1984	1985	1986	1987
United States:					
Mine production ² -----	6	15	W	W	W
Value ³ ----- thousand dollars -----	\$1,118	\$2,456	W	W	W
Refinery production:					
Primary refined -----	9	24	7	^r 4	6
Secondary:					
Nontoll-refined -----	303	340	259	^r 354	165
Toll-refined -----	995	1,157	1,038	^r 1,155	1,444
Total refined metal -----	1,307	1,521	1,304	^r 1,513	1,615
Stocks, yearend:					
Industry (refined) -----	943	1,319	1,129	^r 1,292	1,235
National Defense Stockpile:					
Platinum -----	453	453	453	453	453
Palladium ⁴ -----	1,255	1,262	1,265	1,265	1,265
Iridium ⁵ -----	28	30	30	30	30
Exports:					
Refined ⁶ -----	446	599	526	382	432
Total -----	1,229	1,162	889	751	708
Imports for consumption:					
Refined ⁶ -----	2,790	3,928	3,438	3,727	3,179
Total -----	3,218	4,474	3,990	4,477	3,807
Imports, general -----	3,218	4,485	3,990	4,399	3,807
Consumption (reported sales to industry) -----	1,914	2,200	2,271	^r 2,080	1,944
Consumption, apparent ⁷ -----	2,813	3,299	3,358	^r 3,536	2,969
Net import reliance ⁸ as a percent of apparent consumption -----	89	89	92	^r 90	94
Price, dealer, average, per ounce:					
Platinum -----	\$424	\$357	\$291	\$461	\$553
Palladium -----	\$136	\$148	\$107	\$116	\$130
World: Mine production ⁹ -----	6,525	^r 7,653	7,941	^p 8,314	^e 8,671

¹Estimated. ²Preliminary. ³Revised. W Withheld to avoid disclosing company proprietary data.

⁴The platinum group comprises six metals: platinum, palladium, iridium, osmium, rhodium, and ruthenium.

⁵Byproduct of copper refining.

⁶Value based on dealer prices.

⁷Includes 7,200 ounces purchased in 1984 and 2,400 ounces purchased in 1985, but not added to inventory in those years.

⁸Includes 2,400 ounces purchased in 1983 and another 2,400 ounces purchased in 1984, but not added to inventory in those years.

⁹Includes both unwrought and semimanufactured.

¹⁰1983-84 includes mine production plus nontoll-refined production plus refined imports for consumption minus refined exports plus or minus changes in Government and industry stocks. 1985-87 mine production excluded to avoid disclosing company proprietary data.

¹¹Refined imports for consumption minus refined exports plus or minus changes in Government and industry stocks.

¹²1985-87 totals exclude U.S. mine production to avoid disclosing company proprietary data.

PGM were used for a number of advanced material applications. For example, platinum-iridium alloys were used in crucibles for growing crystals used in computer memory devices and lasers. Platinum was used as a catalyst in the electrodes of phosphoric acid fuel cells, used for generating electricity.

Domestic Data Coverage.—Domestic production data for PGM are developed by the Bureau of Mines from a voluntary survey of U.S. refiners. Of the 24 refiners to which a

survey request was sent, all responded. These represent 100% of the total refined metal production shown in tables 1 and 2.

Legislation and Government Programs.—An advisory panel composed of industry and Government representatives recommended that the Government should add rhodium and ruthenium to the National Defense Stockpile. Currently, the only PGM in the stockpile are platinum, palladium, and iridium.

DOMESTIC PRODUCTION

Exploration for PGM at the Stillwater Complex in Montana was first initiated in 1967 by Manville Corp. In March, SMC, a joint venture of Lac Minerals Ltd., Chevron Corp., and Manville Corp., shipped its first load of PGM concentrate to Métallurgie Hoboken-Overpelt S.A. (MHO) in Belgium. MHO processed the concentrate, which contained about 40 troy ounces of platinum and palladium per short ton. It returned the metal sponge to the partners, who then sold the metals in the spot market. Gold, rhodium, and silver also were recovered by MHO. In 1987, production of platinum was estimated to be 25,000 ounces. Production of palladium was estimated to be 75,000 ounces. By 1990, production of platinum and palladium is projected to double.²

The U.S. Geological Survey reportedly discovered substantial quantities of platinum in gold ore from the Tolovana and Rampart mining districts near Fairbanks,

AK.³ ASARCO Incorporated produced refined platinum and palladium as byproducts of copper refining from their Amarillo, TX, refinery.

Secondary metal was refined by about 24 firms. Most PGM scrap was refined on a toll basis. The largest scrap processor in the United States was Johnson Matthey Inc.

A new company, Catalyst Collectors Corp. (CCC), based in Union, NJ, was formed to collect and process catalytic converter scrap. CCC planned to have its scrap refined through Nippon Engelhard Ltd. in Tokyo, Japan.

The Industrial Products Div. of Heraeus Inc., based in Newark, NJ, announced plans to expand its precious metals recycling program. Heraeus recovers PGM, gold, and silver from scrap generated by the chemical, pharmaceutical, and electronics industries.

Table 2.—Platinum-group metals refined in the United States

(Troy ounces)

	Platinum	Palladium	Iridium	Osmium	Rhodium	Ruthenium	Total
PRIMARY METAL							
Nontoll-refined:							
1983	879	5,005	--	--	--	--	5,884
1984	1,430	13,003	--	--	--	--	14,433
1985	524	3,463	--	--	--	--	3,987
1986	613	3,742	--	--	--	--	4,355
1987	1,032	5,095	--	--	--	--	6,127
Toll-refined:							
1983	1,150	2,026	--	--	--	--	3,176
1984	1,153	4,895	1,000	250	--	2,000	9,298
1985	1,100	--	--	--	--	2,200	3,300
1986	(1)	(1)	--	(1)	--	(1)	(1)
1987	--	--	--	--	--	--	--

See footnote at end of table.

Table 2.—Platinum-group metals refined in the United States —Continued

(Troy ounces)

	Platinum	Palladium	Iridium	Osmium	Rhodium	Ruthenium	Total
SECONDARY METAL							
Nontoll-refined:							
1983 -----	118,579	177,816	2,357	--	3,663	750	303,165
1984 -----	89,702	243,347	735	27	3,668	2,047	339,526
1985 -----	52,383	201,362	252	--	3,126	1,474	258,597
1986 ^r -----	70,867	277,366	297	--	4,316	1,313	354,159
1987 -----	37,939	120,351	115	604	3,944	1,597	164,520
Toll-refined:							
1983 -----	433,700	456,732	5,820	925	41,624	55,788	994,589
1984 -----	524,158	568,489	7,826	49	37,584	19,288	1,157,394
1985 -----	490,595	490,948	7,007	3	36,336	13,356	1,038,245
1986 ^r -----	674,412	398,270	3,584	1,415	57,618	19,701	1,155,000
1987 -----	725,961	616,311	3,269	796	60,930	37,430	1,444,697
1986 TOTALS^r							
Total primary -----	613	3,742	--	(¹)	--	(¹)	4,355
Total secondary -----	745,279	675,636	3,881	1,415	61,934	21,014	1,509,159
Total refined metal -----	745,892	679,378	3,881	1,415	61,934	21,014	1,513,514
1987 TOTALS							
Total primary -----	1,032	5,095	--	--	--	--	6,127
Total secondary -----	763,900	736,662	3,384	1,400	64,874	38,997	1,609,217
Total refined metal -----	764,932	741,757	3,384	1,400	64,874	38,997	1,615,344

^rRevised.¹Revised to zero.

CONSUMPTION AND USES

Domestic industrial consumption of PGM remained essentially the same as that of 1986. PGM were used principally in catalysts for the control of automobile and industrial plant emissions; in reforming catalysts used to upgrade the octane rating of gasolines; and in catalysts used to produce acids, organic chemicals, and pharmaceuticals. They were also used in bushings for making glass fibers used in fiber-reinforced-plastic and other advanced materials, in electrical contacts, in capacitors, in conductive and resistive films used in electronic circuits, and in dental alloys used for making crowns and bridges.

Platinum, palladium, and rhodium were used in emission catalysts for light trucks (weighing 14,000 pounds or less, gross weight) and for automobiles. A typical emission catalyst in 1987 contained 0.057 ounce of platinum, 0.015 ounce of palladium, and 0.006 ounce of rhodium. Historically, quantities of the metals contained in each catalyst have varied. Variation depends on the year the vehicle was manufactured, the vehicle's engine size, the normal operating temperature of the vehicle's engine, and the manufacturer of the catalyst. In 1987, domestic vehicle production was 10.6 million vehicles outfitted with catalytic converters. One-third was light trucks and the rest were automobiles. For comparison, in 1983 domestic production was 9 million vehicles,

with one-quarter of total vehicles being light trucks. Thus, it appears that light trucks are growing in importance in the total vehicle market using catalytic converters.

In electronic applications, ruthenium was the principal PGM used in thick film resistors. Palladium was the principal PGM used in thick-film conductors, multilayer ceramic capacitors, and connectors.

For glass applications, most of the PGM, specifically platinum, rhodium, and palladium, were used in bushings for the extrusion of textile or continuous-filament glass fiber.

In other applications, platinum and iridium crucibles were used for growing oxide single crystals, such as gadolinium gallium garnet (GGG) and yttrium aluminum garnet (YAG). GGG and YAG are used for computer memory devices and solid-state lasers. Platinum with titanium and columbium was used for cathodic protection of steel reinforcing bars in bridge and highway concrete. It prevents their corrosion by deicing salts used on roadways.

The Bureau of Mines does not collect data on domestic investor demand for platinum. According to Johnson Matthey PLC, the mid-range estimate for platinum investment demand in North America decreased to about 100,000 ounces, somewhat less than half of the 1986 level.⁴

Table 3.—Platinum-group metals¹ sold to consuming industries in the United States
(Troy ounces)

Year and industry	Platinum	Palladium	Iridium	Osmium	Rhodium	Ruthenium	Total
1983-----	796,716	921,829	5,023	1,389	44,225	144,777	1,913,959
1984-----	876,227	1,150,500	7,117	1,072	76,253	88,619	2,199,788
1985-----	1,025,765	1,060,319	10,664	885	88,252	85,574	2,271,459
1986:							
Automotive ² -----	625,000	165,000	[†] 93	---	67,000	[†] 500	[†] 857,593
Chemical-----	77,696	44,485	929	17	5,083	24,910	153,120
Dental and medical-----	[†] 20,752	[†] 267,138	372	672	611	98	[†] 289,643
Electrical-----	103,506	[†] 286,390	1,630	---	6,813	61,489	[†] 459,828
Glass-----	[†] 15,945	---	93	---	2,952	20	[†] 19,010
Jewelry and decorative [†] -----	11,330	4,795	1,033	---	3,195	745	21,098
Petroleum-----	30,566	60,959	---	---	---	---	91,525
Miscellaneous-----	[†] 96,209	61,182	8,132	---	7,775	15,202	[†] 188,500
Total [†] -----	981,004	889,949	12,282	689	93,429	102,964	2,080,317
1987:							
Automotive ² -----	605,000	160,000	55	---	63,000	---	828,055
Chemical-----	61,719	34,682	884	---	3,446	2,242	102,973
Dental and medical-----	15,387	333,601	3,252	919	334	341	353,834
Electrical-----	58,545	318,301	882	---	5,775	24,857	408,360
Glass-----	9,157	---	55	---	1,772	24	11,008
Jewelry and decorative-----	5,706	7,099	626	---	7,391	259	21,081
Petroleum-----	23,773	41,344	---	---	---	---	65,117
Miscellaneous-----	45,962	100,239	2,330	---	4,823	630	153,984
Total-----	825,249	995,266	8,084	919	86,541	28,353	1,944,412

[†]Revised.

¹Comprises primary and nontoll-refined secondary metals.

²1984-87 platinum, palladium, and rhodium sales to the automotive industry are estimated based on U.S. light truck sales and U.S. automobile production.

STOCKS

In addition to the stocks reported and held by refiners, importers, and dealers, end users of PGM held sizable quantities of

PGM that were not reported to the Bureau of Mines.

Table 4.—Refiner, importer, and dealer stocks of refined platinum-group metals¹ in the United States, December 31

(Troy ounces)

Year	Platinum	Palladium	Iridium	Osmium	Rhodium	Ruthenium	Total
1983-----	433,457	412,178	16,944	489	51,107	28,973	943,148
1984-----	648,130	524,924	19,600	1,302	53,120	71,571	1,318,647
1985-----	571,725	454,999	16,930	274	47,133	37,618	1,128,679
1986 [†] -----	656,718	545,206	19,649	381	47,417	22,664	1,292,035
1987-----	611,000	558,005	16,275	36	32,018	17,653	1,234,987

[†]Revised.

¹Includes metal in depositories of the New York Mercantile Exchange (NYMEX); on Dec. 28, 1987, this comprised 291,000 troy ounces of platinum and 61,800 troy ounces of palladium.

PRICES

World platinum supply exceeded industrial demand plus investment demand in 1987 by about 280,000 ounces (table 10). As a result, average monthly dealer prices were more often under \$600 per ounce than over \$600 per ounce. Less fluctuation was felt in average monthly dealer prices in 1987 than

in 1986, possibly because of fear in 1986 that the U.S. Congress would impose economic sanctions on purchases of PGM from the Republic of South Africa. Trading volume for platinum and palladium on the New York Mercantile Exchange declined in 1987.

Table 5.—Average producer and dealer prices¹ of platinum-group metals

(Dollars per troy ounce)

	Platinum		Palladium		Rhodium		Iridium		Ruthenium		Osmium	
	Pro- ducer	Dealer	Pro- ducer	Dealer	Pro- ducer	Dealer	Pro- ducer	Dealer	Pro- ducer	Dealer	Pro- ducer	Dealer
1983 -----	475	424	130	136	600	312	600	309	45	28	110	132
1984 -----	475	357	147	148	625	607	600	424	(²)	103	(³)	455
1985 -----	475	291	127	107	915	929	600	438	(²)	101	(³)	915
1986:												
January -	475	365	120	102	1,150	1,149	600	422	(²)	70	(³)	874
February -	475	373	120	101	1,150	1,104	600	425	(²)	71	(³)	854
March ----	475	413	120	110	1,150	1,140	600	440	(²)	75	(³)	850
April ----	475	417	120	107	1,150	1,132	600	427	(²)	72	(³)	887
May -----	475	411	120	108	1,150	1,144	600	407	(²)	69	(³)	633
June -----	475	432	120	110	1,150	1,156	600	399	(²)	70	(³)	650
July -----	475	439	120	111	1,150	1,163	600	396	(²)	69	(³)	650
August ----	505	537	127	128	1,169	1,202	600	406	(²)	70	(³)	650
September -	600	595	150	140	1,300	1,317	600	414	(²)	70	(³)	650
October ----	600	571	150	135	1,364	1,205	600	414	(²)	79	(³)	650
November -	600	510	150	122	1,267	1,101	600	408	(²)	78	(³)	650
December -	600	474	150	117	1,200	1,075	600	407	(²)	77	(³)	650
Average	519	461	131	116	1,196	1,157	600	414	(²)	73	(³)	704
1987:												
January -	600	515	150	123	1,200	1,124	600	397	(²)	74	(³)	650
February -	600	515	150	120	1,200	1,180	600	394	(²)	71	(³)	650
March ----	600	525	150	123	1,200	1,157	600	384	(²)	71	(³)	650
April ----	600	585	150	136	1,200	1,201	600	375	(²)	72	(³)	626
May -----	600	605	150	145	1,200	1,245	600	384	(²)	72	(³)	625
June -----	600	565	150	137	1,220	1,225	600	379	(²)	72	(³)	625
July -----	600	568	150	140	1,275	1,230	507	345	(²)	67	(³)	632
August ----	600	608	150	140	1,275	1,273	600	350	(²)	68	(³)	650
September -	600	586	150	137	1,275	1,272	420	354	(²)	68	(³)	650
October ----	600	564	150	129	1,275	1,270	420	332	(²)	68	(³)	650
November -	600	494	150	111	1,275	1,246	420	330	(²)	67	(³)	600
December -	600	500	150	121	1,275	1,243	420	335	(²)	67	(³)	590
Average	600	553	150	130	1,239	1,222	532	363	(²)	70	(³)	633

¹ Average prices calculated at the low end of the range and rounded to the nearest dollar.² Producer price suspended on June 7, 1984.³ Producer price suspended on Jan. 13, 1984.

Source: Metals Week.

Table 6.—NYMEX trading volume for future contracts, yearend

(Number of contracts)

	1984	1985	1986	1987
Platinum ¹ -	571,127	693,256	1,624,635	1,361,546
Palladium ² -	159,019	133,223	145,562	160,284

¹ 50 troy ounces per contract.² 100 troy ounces per contract.

The European Options Exchange in Amsterdam, in conjunction with stock exchanges in Montreal, Sydney, and Vancouver, opened the world's first platinum options contract. An options contract allows one to buy metal at a specified price for a specified period. Before it expires, an option

can either be sold to another investor or exercised. If exercised, the investor must invest additional funds to purchase metal, according to the terms of the option.

In the United Kingdom, Samuel Montagu Ltd., Aryton Metals Ltd., Sharps Pixley Ltd., Mase Westpac Ltd., Johnson Matthey, and Engelhard Corp., joined to create the London Platinum and Palladium Market, a wholesale professional market. Member firms are exempt from paying value-added taxes on wholesale platinum and palladium transactions. Creation of the London market is expected to increase trading significantly in the next few years. Membership is open to other platinum-palladium traders besides the original six founding members.

Table 7.—U.S. exports of platinum-group metals, by year and country

Year and country	Ores and concentrates (troy ounces)	Waste, scrap, and sweepings (troy ounces)	Metal not rolled (troy ounces)			Metal rolled (troy ounces)		Total	
			Platinum	Palladium	Other platinum group	Platinum	Other platinum group	Troy ounces	Value (thousands)
1983	31,827	751,140	138,928	155,607	71,289	45,671	34,292	1,228,754	\$309,917
1984	40,920	522,425	177,401	182,692	167,635	43,484	27,475	1,162,082	274,775
1985	3,967	358,417	182,487	215,626	87,727	4,526	35,901	888,651	187,161
1986	29,375	339,373	93,112	175,605	86,474	11,043	15,693	750,675	201,807
1987:									
Australia	--	17,346	--	2,893	--	--	--	2,893	165
Belgium-Luxembourg	--	593	--	2,386	5,664	--	--	25,396	10,046
Brazil	--	15,280	--	474	1,971	--	44	3,082	1,229
Canada	2,092	--	25,158	19,144	26,857	2,028	11,028	101,537	38,369
China	724	--	6,813	2,276	7,772	--	--	17,585	5,392
France	--	3,992	--	424	986	205	904	6,511	1,397
Germany, Federal Republic of	--	4,592	41	8,676	10,391	474	2,027	26,201	6,884
Israel	--	--	15	55	1,513	--	--	1,583	387
Italy	--	46,482	374	--	2,259	238	200	49,553	12,137
Japan	170	16,087	42,747	52,716	20,907	4,147	231	137,005	47,755
Korea, Republic of	1,244	--	12	861	109	110	3	2,339	296
Mexico	--	115	166	121	1,863	198	344	2,307	1,379
Netherlands	--	--	23	22,096	497	17	1,084	23,717	3,851
Norway	--	--	--	684	661	--	--	1,345	497
Singapore	--	--	350	3,576	513	--	--	4,439	1,170
South Africa, Republic of	--	--	--	--	3,422	--	--	3,422	1,223
Sweden	--	13,544	--	141	5,245	--	--	18,930	4,383
Switzerland	1,000	9,574	98	6,238	13,616	--	--	30,526	9,388
Taiwan	--	--	183	5,021	82	--	--	5,286	1,155
United Kingdom	--	143,642	6,209	55,295	31,333	370	1,293	238,142	75,803
Other	300	--	160	920	4,448	72	98	5,998	2,063
Total	5,530	271,197	82,349	183,997	140,109	7,859	17,256	708,297	224,969

Source: Bureau of the Census.

Table 8.—U.S. imports for consumption of platinum-group metals, by year and country

Year and country	Unwrought (troy ounces)							Platinum-group metals from precious metal ores	Unspeci- fied comb- inations	Ruthenium	Rhodium	Sweepings, waste, and scrap
	Platinum grains and nuggets	Platinum sponge	Palladium	Iridium	Osmium	Osmiri- dium	Ruthenium					
1983	8,513	1,005,208	1,223,951	23,286	1,747	848	119,958	18,143	18,143	163,823	119,958	417,431
1984	19,786	1,527,841	1,795,939	18,225	1,630	150	155,671	8,822	8,822	198,257	155,671	526,738
1985	20,827	1,464,645	1,396,810	20,972	5,153	—	201,028	10,330	10,330	162,887	201,028	580,724
1986	10,465	1,713,971	1,387,131	30,368	5,776	4,500	179,068	19,864	19,864	176,580	179,068	737,813
1987:												
Argentina	87	—	—	—	—	—	—	—	—	—	—	3,468
Australia	203	195	5,786	—	—	—	—	—	—	—	—	109,225
Belgium-Luxembourg	12	30,894	120,947	—	—	—	1,254	34	34	—	—	2,027
Botswana	—	—	2,000	—	—	—	—	—	—	—	—	—
Canada	396	4,075	48,059	—	—	—	—	50	50	3,000	—	130,111
China	81	1,043	977	—	—	—	76	280	280	2,000	—	310
Colombia	28	—	—	—	—	—	—	—	—	—	—	—
Denmark	—	—	2,344	—	—	—	—	—	—	—	—	—
El Salvador	—	—	—	—	—	—	—	—	—	—	—	2,129
Finland	—	—	2,253	—	—	—	—	—	—	—	—	88
France	—	2,160	14	106	—	—	—	—	—	—	—	—
Germany, Federal Republic of	—	9,173	44,114	2,309	449	—	273	300	300	1,140	—	12,404
Hong Kong	—	611	24,436	224	—	—	690	—	—	—	—	182,755
Italy	—	22,344	20,448	—	—	—	462	—	—	—	—	—
Japan	—	696	9,635	—	—	—	—	—	—	138	—	69
Mexico	—	10	—	—	—	—	—	—	—	—	—	—
Netherlands	—	1,883	126,985	—	—	5,800	25,487	2,101	2,101	—	—	57,440
Norway	—	500	—	—	—	—	—	—	—	—	—	—
South Africa, Republic of	—	882,433	696,182	8,339	1,530	—	108,856	1,475	1,475	55,611	—	22,789
Sweden	—	—	—	—	—	—	—	—	—	—	—	15,703
Taiwan	—	—	15,103	—	—	—	—	—	—	—	—	20,436
U.S.S.R.	—	13,957	224,427	317	—	—	42,529	—	—	822	—	—
United Kingdom	11	145,201	185,401	519	69	—	30,769	432	432	21,858	—	62,342
Venezuela	3	—	—	—	—	—	—	2,647	2,647	—	—	17
Other	—	8,653	—	—	—	—	815	—	—	—	—	3,543
Total	821	1,124,018	1,522,161	11,814	2,048	5,800	211,466	7,983	7,983	84,399	211,466	624,916

Table 8.—U.S. imports for consumption of platinum-group metals, by year and country—Continued

Year and country	Semimanufactured (troy ounces)					Platinum-group metals in materials not elsewhere specified (troy ounces)	Total	
	Platinum	Palladium	Iridium	Rhodium	Unspecified combinations		Troy ounces	Value (thousands)
1983	109,376	108,247	213	11,245	—	4,116	3,218,022	\$752,756
1984	60,140	158,012	164	2,389	—	332	4,474,106	1,118,088
1985	78,206	84,492	3,700	145	10	7,977	3,989,594	1,026,592
1986	94,655	114,596	4	1	2	513	4,477,177	1,346,715
1987:								
Argentina	—	—	—	—	—	—	3,555	2,001
Australia	—	—	—	—	—	—	115,443	2,734
Belgium-Luxembourg	—	—	—	—	—	—	195,134	35,330
Botswana	—	—	—	—	—	—	3,000	498
Canada	1,857	11	—	—	—	49	187,869	35,568
China	—	—	—	—	—	—	2,946	1,715
Colombia	1,960	—	—	—	—	208	2,196	1,083
Denmark	—	—	—	—	—	—	2,944	399
El Salvador	—	—	—	—	—	—	2,329	320
Finland	—	—	—	—	—	—	5,380	1,336
France	—	—	—	—	3,875	—	2,580	1,513
Germany, Federal Republic of	—	1,992	—	—	—	—	71,954	17,670
Hong Kong	289	659	—	—	—	—	209,664	13,357
Italy	—	—	—	—	—	—	13,454	2,376
Japan	490	1	—	—	—	—	11,029	2,368
Mexico	—	—	—	—	—	—	57,589	1,414
Netherlands	—	52	—	—	—	—	162,308	49,156
Norway	—	—	—	—	—	—	23,289	4,156
South Africa, Republic of	—	5,000	—	—	—	—	1,759,436	727,045
Sweden	—	—	—	—	—	—	15,703	10,183
Taiwan	—	2,244	—	—	—	—	37,783	10,743
U.S.S.R.	7,978	90,620	—	160	—	—	980,910	101,486
United Kingdom	32,583	50,680	65	669	—	—	530,429	205,064
Venezuela	—	—	—	—	—	—	2,727	905
Other	647	240	—	—	3	—	14,386	7,763
Total	45,804	151,499	65	829	3,878	257	3,806,547	1,240,080

Source: Bureau of the Census.

Table 9.—Estimated U.S. imports of platinum, palladium, and rhodium, by country¹
(Thousand troy ounces)

Country	Platinum		Palladium		Rhodium	
	1986	1987	1986	1987	1986	1987
South Africa, Republic of	1,178	883	531	702	98	109
U.S.S.R.	45	22	247	315	25	43
United Kingdom	366	209	337	267	38	31
Other	483	376	857	716	33	29
Total ²	2,073	1,490	1,972	2,000	195	212

¹This table is based on the figures shown in table 8. Estimates are based on the explicit categories of platinum, palladium, and rhodium plus estimates of the metal content in the following categories: unspecified combinations, ores, and scrap, and materials not elsewhere specified.

²Data may not add to totals shown because of independent rounding.

WORLD REVIEW

Three companies in the Republic of South Africa produced PGM from platinum ores. The U.S.S.R. and two companies in Canada produced PGM from nickel-copper ores. The South African companies were Rustenburg Platinum Mines Ltd., Impala Platinum Holdings (Pty.) Ltd., and Western Platinum Ltd.; the Canadian companies were Inco Ltd. and Falconbridge Nickel Mines Ltd. World production of platinum was 3.8 million ounces and world production of palladium was 4.0 million ounces, of which the U.S.S.R. produced an estimated 980,000 ounces of platinum and 2.6 million ounces of palladium.

World platinum supply exceeded industri-

al demand plus investment demand by about 280,000 ounces in market economy countries (table 10). Palladium and rhodium supply and demand were fairly balanced. According to Johnson Matthey, investment demand in 1987 was only half of its 1986 level, possibly because of uncertain world economic and political conditions in 1986.

Nineteen eighty-seven marked a year of intense exploration for PGM. The Republic of South Africa, Canada, Australia, and New Zealand reported the most activity.

Australia.—Australia planned to produce legal tender platinum bullion coins, in 1-ounce, 1/2-ounce, 1/4-ounce, and 1/10-ounce weights.

Table 10.—Supply and demand for platinum, palladium, and rhodium in 1987
(Thousand troy ounces)

	Platinum	Palladium	Rhodium
SUPPLY			
Mine production (market economy countries):			
South Africa, Republic of ^a	2,600	1,100	130
Canada	186	195	17
Other	39	68	—
Total	2,825	1,363	147
Secondary from old scrap:			
Japan	45	200	7
United States	37	117	4
Other	10	150	2
Total	92	467	13
Soviet sales to market economy countries	459	1,609	54
Total	3,376	3,439	214

See footnote at end of table.

Table 10.—Supply and demand for platinum, palladium, and rhodium in 1987
—Continued

(Thousand troy ounces)

	Platinum	Palladium	Rhodium
DEMAND			
Industrial:			
Japan	1,352	1,644	100
United States	825	995	87
Western Europe	500	560	20
Other	200	200	5
Total	2,877	3,399	212

^aEstimated.¹Excludes approximately 220,000 ounces of investment demand.

Sources: Johnson Matthey PLC, CPM Group Ltd., and Bureau of Mines estimates.

Belgium-Luxembourg.—Johnson Matthey announced plans to build a new automobile catalyst manufacturing plant in Eyre to complement the company's existing facility in Royston, United Kingdom. The plant will have a capacity of 4.5 million exhaust catalysts per year, making it one of the largest plants in Europe. The new plant is expected to produce catalysts by the end of 1988. It will help meet a European Economic Community directive requiring all new car models with engines larger than 2 liters to be fitted with converters after October 1988.

Canada.—Madeleine Mines Ltd. of Toronto said that it would develop its Lac des Iles platinum-palladium deposit. The company plans to build a smelter at Thunder Bay and a refinery in Calgary to process the output of its 3,000-short-ton-per-day open pit mine. The mine could be producing 15,000 ounces of platinum and 120,000 ounces of palladium by 1988.⁵

International Platinum Corp. owns interests in over 20 PGM properties. It explored for PGM in Canada and the United States. Among its most promising Canadian properties were Big Trout Lake, Ontario; Lac des Iles, Ontario; Delta Sill, Quebec; and Red Lake, Ontario. Degussa AG of the Federal Republic of Germany, a major world refiner and fabricator of precious metals, entered into a joint venture agreement with International Platinum. Degussa was to acquire a 50% interest in properties owned by International Platinum, but In-

ternational Platinum would remain as operator of the joint venture. Degussa was to provide some of the \$4.5 million budgeted for exploration of the properties over the next 3 years.⁶

France.—The French Government issued its first commemorative platinum and palladium coins in celebration of the bicentennial of the French Revolution. The platinum coins weigh 20 grams and the palladium coins weigh 17 grams. Manfra, Tordella & Brookes Inc. of New York was the exclusive distributor in North America.

Korea, Republic of.—In a joint venture, Hankuk Engelhard Corp. and Hyundai Motor Co. planned to build an automotive exhaust catalyst manufacturing plant in Ahnsahn city. Hankuk Engelhard is owned by Engelhard Corp. and Hi-Seong Metal Industries Co. Ltd. Startup of the plant was expected in the fourth quarter of 1987.

South Africa, Republic of.—All three of the PGM producers in the Republic of South Africa—Rustenburg Platinum Mines Ltd., Impala Platinum Holdings (Pty.) Ltd., and Western Platinum—announced major expansion plans in 1987.

Rustenburg decided to expand production of PGM at its Atok Mine and possibly develop a mine at its deposit at Maandagshoek, both in the black homeland of Lebowa. Together, the two deposits were to be known as Lebowa Platinum Mines Ltd. and would be listed on the Johannesburg Stock Exchange. Lebowa could produce as much as 300,000 ounces of PGM per year by 1991.⁷

Impala planned to build a new mine near Marikana that would produce 100,000 ounces per year of platinum by 1991. Eventually it would increase to 300,000 ounces per year. The new mine, called Karee, was expected to replace declining production from Impala's existing mines.⁹

Western Platinum planned to double its output of PGM to 500,000 ounces per year by 1992 or 1993. The additional production was expected to be mined from the UG-2 reef.⁹

Between 1989 and 1993, five new PGM companies presumably will begin mining the Merensky and UG-2 reefs of the Bushveld Complex in the Republic of South Africa. It was projected that South Africa production of platinum could grow from an estimated 2.5 million ounces in 1987 to 3.5 million ounces by the early 1990's. Some of the new production was no doubt spurred by the need to supply the growing demand for PGM in the autocatalyst market.

Northam Platinum Ltd., a subsidiary of Gold Fields of South Africa Ltd., continued to develop its deep mine near Rustenburg's Amandelbult section. Mining at depths of over 6,600 feet, the project was expected to require elaborate refrigeration facilities. Initial production of 250,000 ounces per year of PGM was slated to begin by 1991. By 1994, Northam could produce 350,000 ounces per year of PGM. Up to 200,000 ounces of this total would be platinum.

Golden Dumps Ltd. announced plans to develop a new PGM mine to exploit the UG-2 reef, to be called Lefkochrysos, near the town of Brits. Production was expected

to be 170,000 ounces per year of PGM by 1989, mined from deposits only 65 feet below the surface. Other deposits, over 3,000 feet deep, could eventually be producing about 650,000 ounces per year of PGM, of which 350,000 ounces per year would be platinum.¹⁰

Rand Mines Ltd. and Vansa Vanadium S.A. Ltd. agreed to develop a new PGM mine, near Lydenburg. It would initially produce about 435,000 ounces per year of PGM (140,000 ounces per year of platinum) beginning about 1992. The new mine, called Rhodium Reefs, was to mine the UG-2 reef exclusively.¹¹

In Lebowa, another company, Messina Ltd., announced that it would begin trial mining and metallurgical testing of PGM from a mine being developed at Zebediella, east of Rustenburg's Atok Mine. When developed, the mine is expected to produce 150,000 ounces of platinum by 1993.¹² Also in Lebowa, Severin Mining and Development Inc. planned to open a new, very deep platinum mine by 1990.¹³

Zimbabwe.—Two Australian companies, Delta Gold and Mumbil Mines, announced the formation of a joint venture to consider development of a portion of the Great Dyke in Zimbabwe in an area called the Hartley project, which was previously explored by Union Carbide Corp. between 1968 and 1972. Delta and Mumbil hoped to develop the Hartley project into an operation with an annual output of 100,000 ounces of platinum, 80,000 ounces of palladium, and 30,000 ounces of gold.¹⁴

Table 11.—Platinum-group metals: World production, by country¹

(Troy ounces)

Country ²	1983	1984	1985	1986 ³	1987 ⁴
Australia, metal content, from domestic nickel ore: ³					
Palladium	*12,000	16,815	15,304	13,760	15,800
Platinum	*1,900	2,122	3,054	3,697	4,200
Canada: Platinum-group metals from nickel ore	223,925	348,216	337,088	391,917	*433,681
Colombia: Placer platinum	10,303	10,106	11,650	14,368	15,000
Ethiopia: Placer platinum ⁵	125	125	*150	*150	150
Finland:					
Palladium	2,283	1,093	1,125	3,086	3,000
Platinum	2,186	1,061	1,125	3,858	4,000
Japan, metal recovered from nickel-copper ores: ⁵					
Palladium	37,122	33,802	43,703	46,699	*45,558
Platinum	21,460	19,523	22,216	21,312	*24,209
South Africa, Republic of: Platinum-group metals from platinum ore ⁶	2,600,000	3,500,000	3,700,000	*3,960,000	4,220,000
U.S.S.R.: Placer platinum and platinum-group metals recovered from nickel-copper ores ⁶	3,600,000	3,700,000	3,800,000	3,850,000	3,900,000

See footnotes at end of table.

Table 11.—Platinum-group metals: World production, by country¹—Continued

(Troy ounces)					
Country ²	1983	1984	1985	1986 ^p	1987 ^e
United States: Placer platinum and platinum-group metals from gold-copper ores -----	6,257	14,635	W	W	W
Yugoslavia: ⁴					
Palladium -----	⁴ 2,926	3,100	3,300	^r 3,100	3,100
Platinum -----	⁴ 193	200	250	^r 250	250
Zimbabwe:					
Palladium -----	2,395	1,222	965	1,125	1,150
Platinum -----	1,695	772	611	836	850
Total -----	6,524,770	^r 7,652,792	7,940,541	8,314,158	8,670,948

^eEstimated. ^pPreliminary. ^rRevised. W Withheld to avoid disclosing company proprietary data; not included in "Total."

¹Table includes data available through May 6, 1988. Platinum-group metal production by the Federal Republic of Germany, Norway, and the United Kingdom is not included in this table because the production is derived wholly from imported metallurgical products and to include it would result in double counting.

²In addition to the countries listed, China, Indonesia, Papua New Guinea, and the Philippines are believed to produce platinum-group metals, and several other countries may also do so, but output is not reported quantitatively, and there is no reliable basis for the formulation of estimates of output levels. However, a part of this output not specifically reported by country is presumably included in this table credited to Japan. (See footnote 5.)

³Partial figure; excludes platinum-group metals recovered in other countries from nickel ore of Australian origin; however, a part of this output may be credited to Japan. (See footnote 5.)

⁴Reported figure.

⁵Japanese figures do not refer to Japanese mine production, but rather represent Japanese smelter-refinery recovery from ores originating in a number of countries; this output cannot be credited to the country of origin because of a lack of data. Countries producing and exporting such ores to Japan include (but are not necessarily limited to) Australia, Canada, Indonesia, Papua New Guinea, and the Philippines. Output from ores of Australian, Indonesian, Papua New Guinean, and Philippine origin are not duplicative, but output from Canadian material might duplicate a part of reported Canadian production.

⁶Includes osmiridium produced in gold mines.

TECHNOLOGY

The Davison Div. of W. R. Grace & Co. developed a new metal substrate catalytic converter for controlling pollution emissions from car exhausts and power stations. The substrate is made of thin metal foil, formed into corrugations, stacked and retained by rings on both edges. The new metal substrates reportedly have improved thermal durability over conventional ceramic substrates.¹⁵

Mitsui & Co. of Cleveland, OH, marketed a system for recovering precious metals from scrapped automobile catalytic converters. System capacities ranged from 1 short ton per day to more than 20 tons per day of crushed catalyst material. The metals are dissolved in hydrochloric acid and deposited electrolytically on carbon particles, filtered, and redissolved in hydrochloric acid. The pure metals can then be selectively precipitated.¹⁶

plement. Production Flows Faster Than Stillwater Projections. V. 95, No. 240, Dec. 11, 1987, p. 8A.

³American Metal Market. Platinum Found in Alaska Gold. V. 95, No. 187, Sept. 25, 1987, pp. 1, 8.

⁴Robson, G. G. Platinum, 1987 Interim Review, Johnson Matthey PLC. P. 11.

⁵London Mining Journal. Lac des Iles Decision. V. 309, No. 7930, Aug. 14, 1987, p. 125.

⁶Metal Bulletin Monthly. Platinum Price Drives PGM Bandwagon. No. 204, Dec. 1987, pp. 14-16.

⁷Metals Week. Rustenburg To Double Atok's Output. V. 58, No. 42, Oct. 19, 1987, p. 8.

⁸Metals Week. Impala To Establish New Platinum Mine. V. 58, No. 43, Oct. 26, 1987, p. 7.

⁹Metal Bulletin. Westplat To Double Output. No. 7168, Mar. 13, 1987, p. 13.

¹⁰London Mining Journal. A Proliferation of Platinum Projects. V. 309, No. 7932, Aug. 28, 1987, pp. 166-167.

¹¹Salak, J. American Metal Market. Huge S. African Platinum Mine May Open in '92. V. 95, No. 155, Aug. 11, 1987, pp. 1, 6.

¹²Metal Bulletin. Messina Platinum Mine Gets Go-Ahead. No. 7208, Aug. 6, 1987, p. 9.

¹³Metals Week. A New Platinum Mine Is Being Planned. V. 58, No. 41, Oct. 12, 1987, p. 8.

¹⁴Mining Journal. Great Dyke Attracts Australians. V. 309, No. 7939, Oct. 16, 1987, p. 305.

¹⁵Materials Edge. Grace Moves Into U.S. Metal Catalytic Converters. No. 1, Sept.-Oct. 1987, p. 9.

¹⁶International Precious Metals Institute. Precious Metals Recovery From Catalytic Converters. V. 11, No. 9, Sept. 1987, p. 4.

¹Physical scientist, Branch of Nonferrous Metals.

²American Metal Market, Platinum-Group Metals Sup-