Precious Metals Depletion

L. David Roper
http://arts.bev.net/roperldavid

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Chapter 1. Silver

Silver is a very important industrial metal because of it has the highest electrical and thermal conductivity of any metal and it is very ductile and malleable. It has been used for making currency coins for many millennia. It is used extensively in electronic products and as a catalyst for chemical reactions. For more details about silver see http://en.wikipedia.org/wiki/Silver.

Data

The silver data used in this analysis are taken from:
http://www.gold-eagle.com/editorials_05/zurbuchen011506.html
http://minerals.usgs.gov/ds/2005/140
http://minerals.usgs.gov/minerals/pubs/commodity/silver/silvemcs06.pdf (reserves and reserves base).

To convert data from tonnes (metric tons) to troy ounces multiply by 32150. All data used for silver are in units of 10^6 troy ounces.

	Reserves (10^6 troy ounces)	Reserves Base (10^6 troy ounces)	Already Extracted to 2005
United States:	804	2572	6430
World:	8680	18,326	35,524

See Appendix 1. Definitions for definitions of “reserves” and “reserves base”.

United States Silver Extraction

Figure 1-1 shows a double Verhulst-function fit (**Roper, 1976**) to the United States silver extraction data with the following parameters:

US Parameters	
Q_1	7386 x 10^6 troy ounces
T_1	1940 year
t_1	10.7 years
n_1	7.29
Q_2	899 x 10^6 troy ounces
T_2	1995 year
t_2	6.2 years
n_2	1

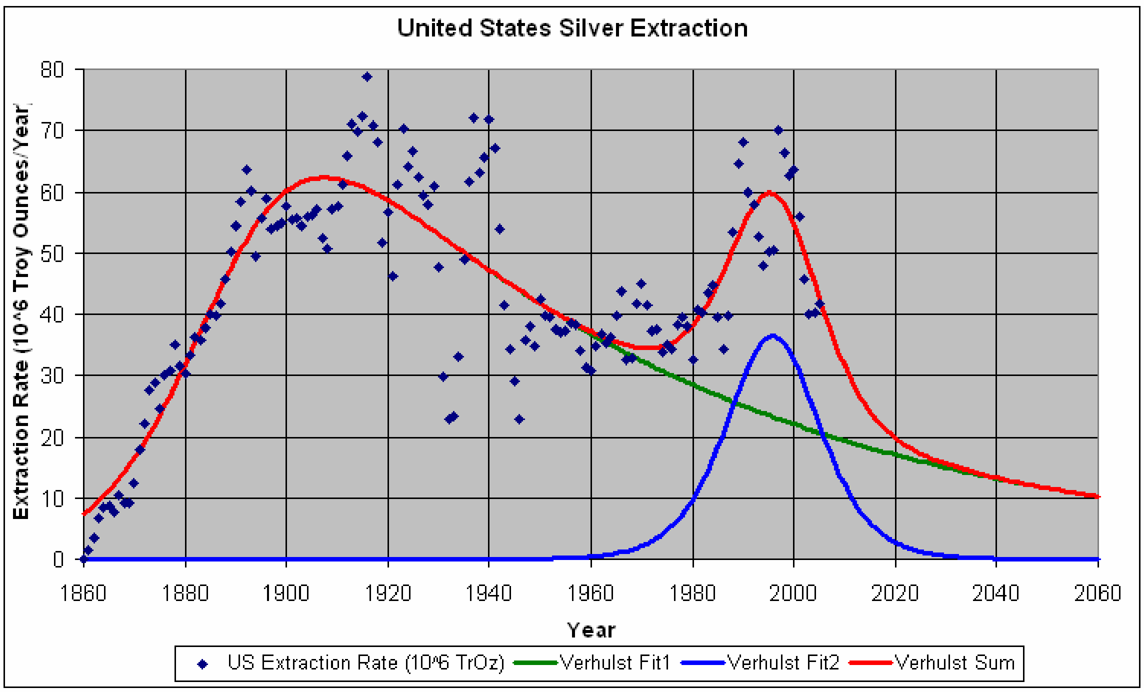

Figure 1-1. Double Verhulst function fit to the United States silver extraction data.

The sum of the Qs ($Q_1 + Q_2$) for the two Verhulst functions is 8284x10^6 troy ounces. The amount extracted by 2005 was 6430x10^6 troy ounces. The reserves plus the amount extracted is 7234x10^6 troy ounces and the reserves base plus the amount extracted is 9002x10^6 troy ounces. So the sum of the Qs lies between the reserves plus the amount extracted and the reserves base plus the amount extracted, which seems quite reasonable.

The recent small silver peak since 1980 is due to the advent of the electronics industry's massive use of silver for conductors.

It appears that silver is highly depleted in the United States, although it is possible that another small extraction peak will occur when it becomes difficult to get silver from the rest of the World.

World Silver Extraction

Figure 1-2 shows a double Verhulst-function fit (**Roper, 1976**) to the World silver extraction data with the following parameters:

World Parameters	
Q_1	13753 x 10^6 troy ounces
T_1	1917 year
t_1	18.6 years
n_1	1.04
Q_2	81351 x 10^6 troy ounces
T_2	2031 year
t_2	25.1 years
n_2	1

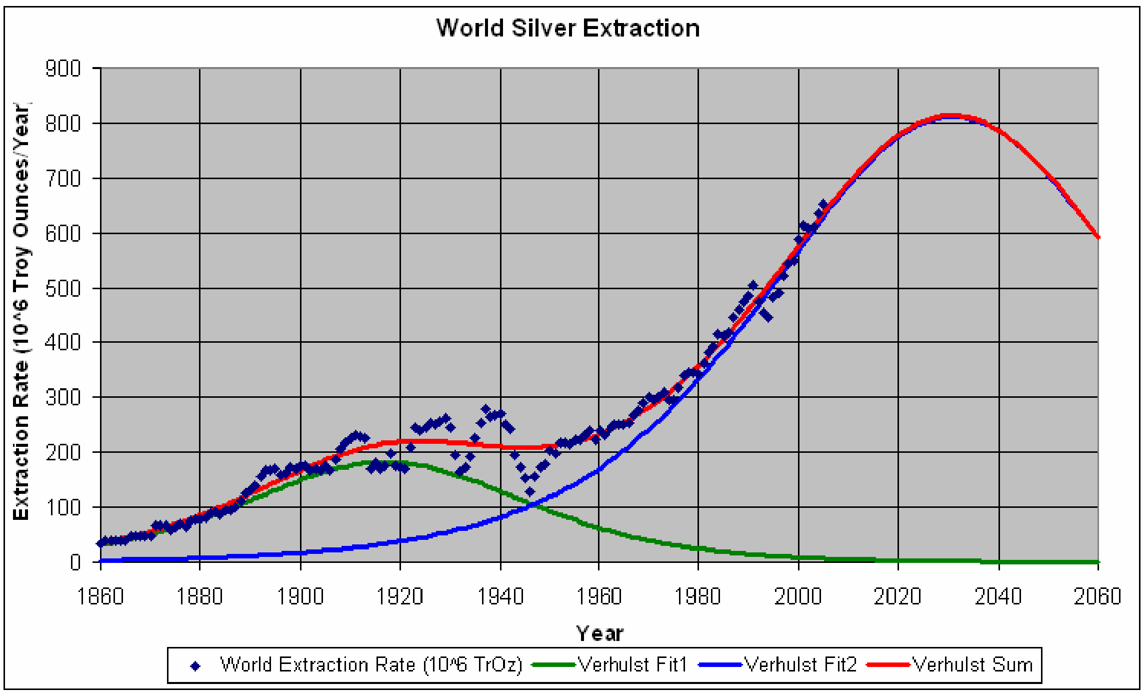

Figure 1-2. Double Verhulst function fit to the World silver extraction data.

The sum of the Qs ($Q_1 + Q_2$) for the two Verhulst functions is 95,105x10^6 troy ounces. The amount extracted by 2005 was 34,524x10^6 troy ounces. The reserves plus the amount extracted is 43,205x10^6 troy ounces and the reserves base plus the amount extracted is 52,850x10^6 troy ounces. So the sum of the Qs is more than twice the reserves plus the amount extracted and less than twice the reserves base plus the amount extracted. That is, there is probably a much larger amount of silver yet to be discovered in the World.

Probably about the year 2030 World silver extraction will peak and the uses of new silver in technology will have to diminish. Recycling of silver in technological devices will become more important than it now is regarded.

Silver Price

Figure 1-3. compares the World silver extraction rate with the silver price in $ per troy ounces.

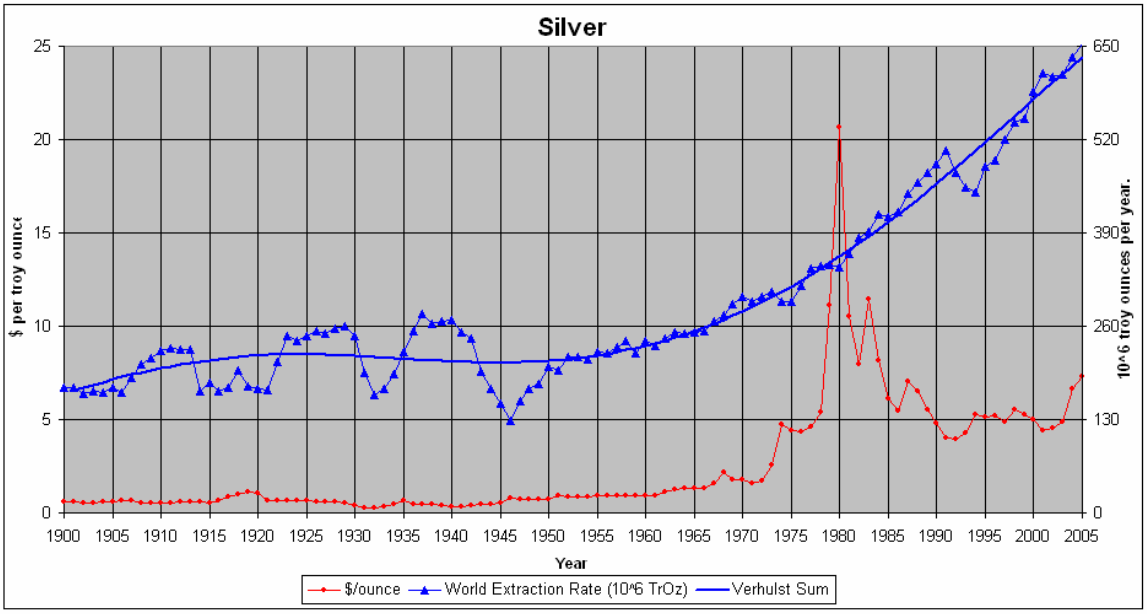

Figure 1-3. World silver extraction rate in 10^6 troy ounces per year compared to silver price in $ per troy ounce.

I see no obvious correlation between the extraction rate and the price.

Chapter 2. Gold

Gold has been used for making currency coins for many millennia. It is still the basis for an international monetary standard. Since about 1980 it has been used extensively in electronic. It is the most ductile and malleable of all metals and is a good conductor of electricity and heat. For more details about gold see http://en.wikipedia.org/wiki/Gold.

Data

The gold data used in this analysis are taken from:
http://www.gold-eagle.com/editorials_05/zurbuchen011506.html
http://minerals.usgs.gov/ds/2005/140
http://minerals.usgs.gov/minerals/pubs/commodity/gold/gold_mcs06.pdf (reserves and reserves base).

To convert data from tonnes (metric tons) to troy ounces multiply by 32150. All data used for gold are in units of 10^6 troy ounces.

	Reserves (10^6 troy ounces)	Reserves Base (10^6 troy ounces)	Already Extracted to 2005
United States:	86.8	603	484
World:	1350	2894	4439

See Appendix 1. Definitions for definitions of “reserves” and “reserves base”.

United States Gold Extraction

Figure 2-1 shows a double Verhulst-function fit (**Roper, 1976**) to the United States gold extraction data with the following parameters:

US Parameters	
Q_1	346 x 10^6 troy ounces
T_1	1914 year
t_1	25.6 years
n_1	1
Q_2	468 x 10^6 troy ounces
T_2	2012 year
t_2	2.26 years
N_2	15.1

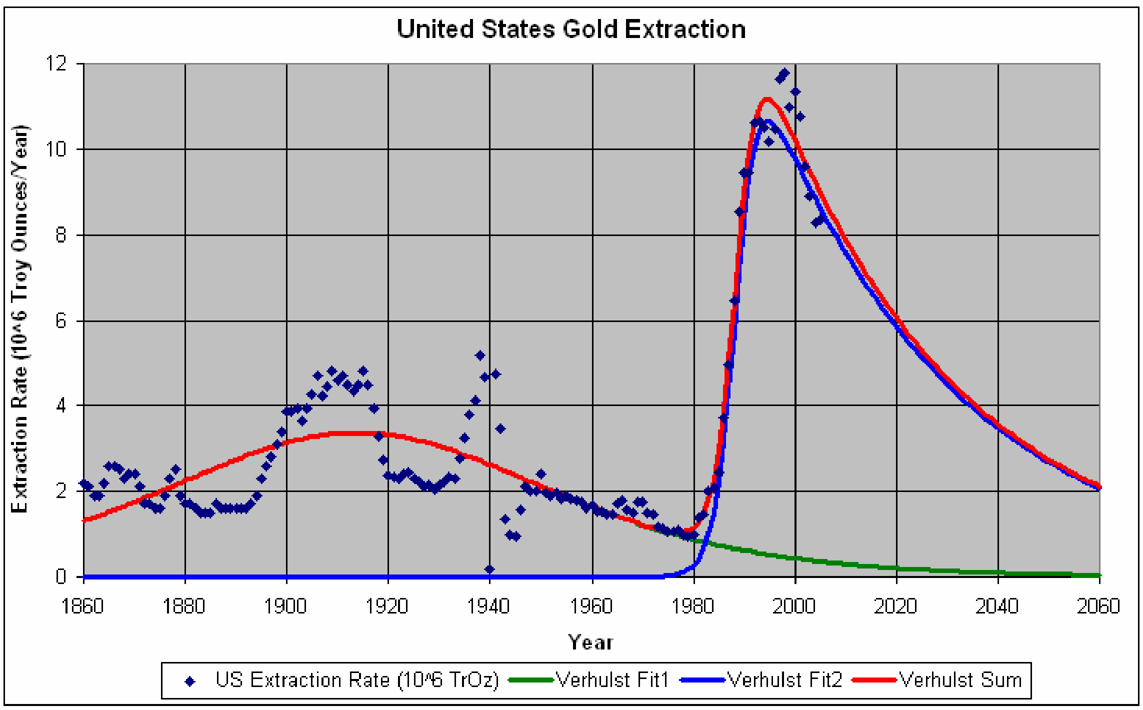

Figure 2-1. Double Verhulst function fit to the United States gold extraction data.

The sum of the Qs ($Q_1 + Q_2$) for the two Verhulst functions is 814x10^6 troy ounces. The amount extracted by 2005 was 484x10^6 troy ounces. The reserves plus the amount extracted is 571x10^6 troy ounces and the reserves base plus the amount extracted is 603x10^6 troy ounces. So the sum of the Qs is larger than the reserves plus the amount extracted and the reserves base plus the amount extracted.

The recent large gold peak since 1980 is due to the advent of the electronics industry's massive use of gold for conductors.

It appears that gold is highly depleted in the United States, although it is possible that another small extraction peak will occur when it becomes difficult to get gold from the rest of the World.

World Gold Extraction

Figure 1-2 shows a double Verhulst-function fit (**Roper, 1976**) to the World gold extraction data with the following parameters:

World Parameters	
Q_1	5333 x 10^6 troy ounces
T_1	1976 year
t_1	31.6 years
n_1	1
Q_2	2241 x 10^6 troy ounces
T_2	2016 year
t_2	3,81 years
n_2	9.00

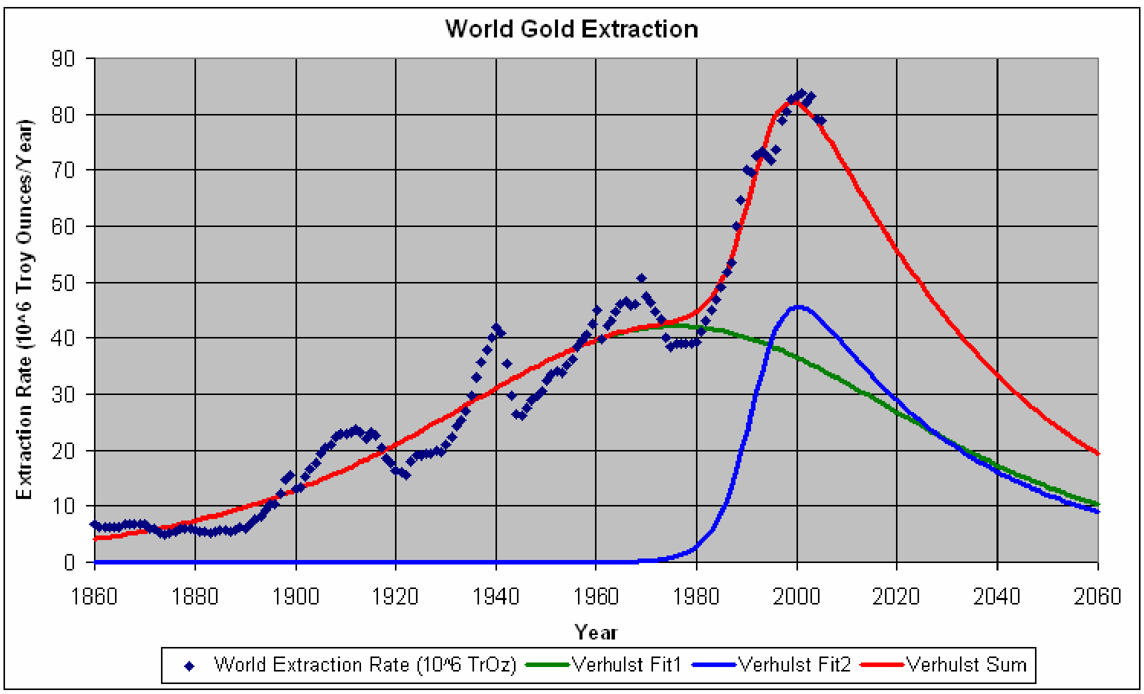

Figure 2-2. Double Verhulst function fit to the World gold extraction data.

The sum of the Qs ($Q_1 + Q_2$) for the two Verhulst functions is 7574x10^6 troy ounces. The amount extracted by 2005 was 4439x10^6 troy ounces. The reserves plus the amount extracted is 5789x10^6 troy ounces and the reserves base plus the amount extracted is 7333x10^6 troy ounces. So the sum of the Qs is slightly more the reserves base plus the amount extracted.

It appears that the World gold extraction has peaked, but there may be more peaks in the future. Of course, eventually the uses of new gold in technology will have to diminish. Recycling of gold in technological devices will become more important than it now is regarded,

Gold Price

Figure 2-3. compares the World gold extraction rate with the gold price in $ per troy ounces.

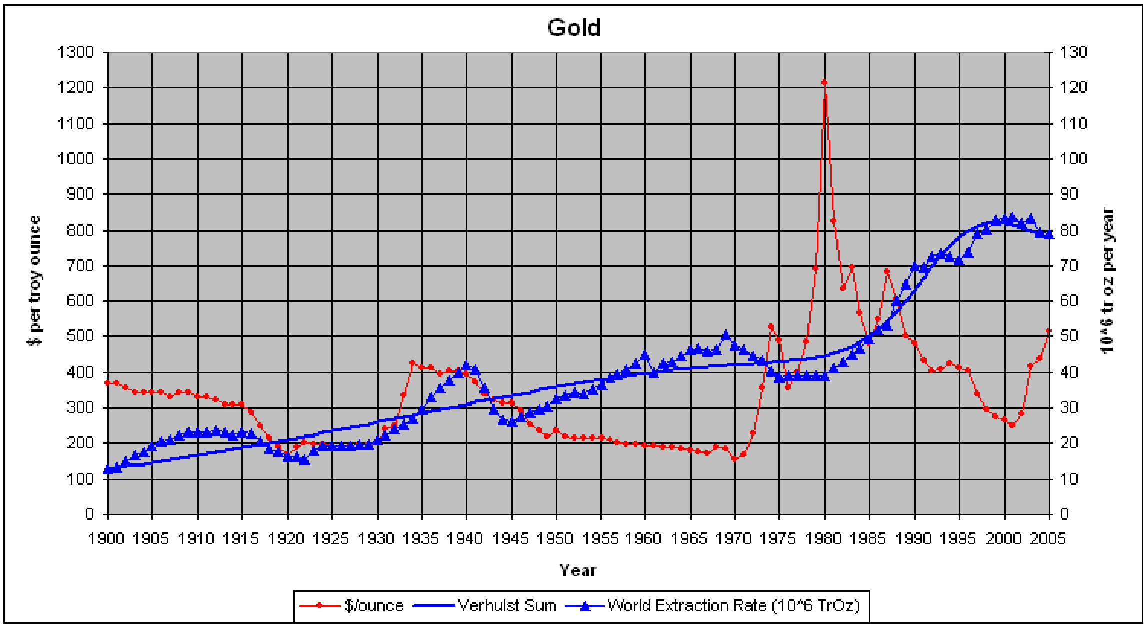

Figure 2-3. World gold extraction rate in 10^6 troy ounces per year compared to gold price in $ per troy ounce.

There appear to be obvious correlations as follows:

- The high price around 1900 must have had some effect on creating the extraction peak around 1910. Note that, as the extraction ramped up, the price went down.
- The high price around 1935 must have had some effect on creating the extraction peak of 1940. Note that, as the extraction ramped up, the price went down, even when the extraction went down for a few years.
- The high price peak of 1980 must have had some effect on the extraction peak of 2000. Note that, as the extraction ramped up, the price went down.

To no great surprise, it appears that extraction rate usually is dependent on the price with a time lag, rather than the reverse. The lag varies from price peak to price peak; the average lag is fourteen years.

Chapter 3. Platinum Group

Platinum and palladium have, since about 1980, been used extensively as a catalyst in chemical reactions and pollution-prevention devices in vehicles.. For more details about platinum group metals see http://en.wikipedia.org/wiki/Platinum and http://en.wikipedia.org/wiki/Palladium and http://en.wikipedia.org/wiki/Platinum_group. (There are six platinum group metals; here we only consider platinum and palladium, the most widely used of the group in industry.)

Data

The platinum-group data used in this analysis are taken from:
http://minerals.usgs.gov/ds/2005/140
http://minerals.usgs.gov/minerals/pubs/commodity/platinum/platimcs06.pdf (reserves and reserves base).

	Reserves (metric tonnes)	Reserves Base (metric tonnes)	Already Extracted to 2005
United States:	86.8	603	484
World:	1350	2894	4439

See Appendix 1. Definitions for definitions of "reserves" and "reserves base".

United States Platinum-Group Extraction

Figure 2-1 shows a double Verhulst-function fit (**Roper, 1976**) to the United States platinum-group extraction data with the following parameters:

US Parameters	
Q_1	29.9 metric tonnes
T_1	1952 year
t_1	7.57 years
n_1	1
Q_2	1140 metric tonnes
T_2	2024 year
t_2	5.62 years
N_2	6.45

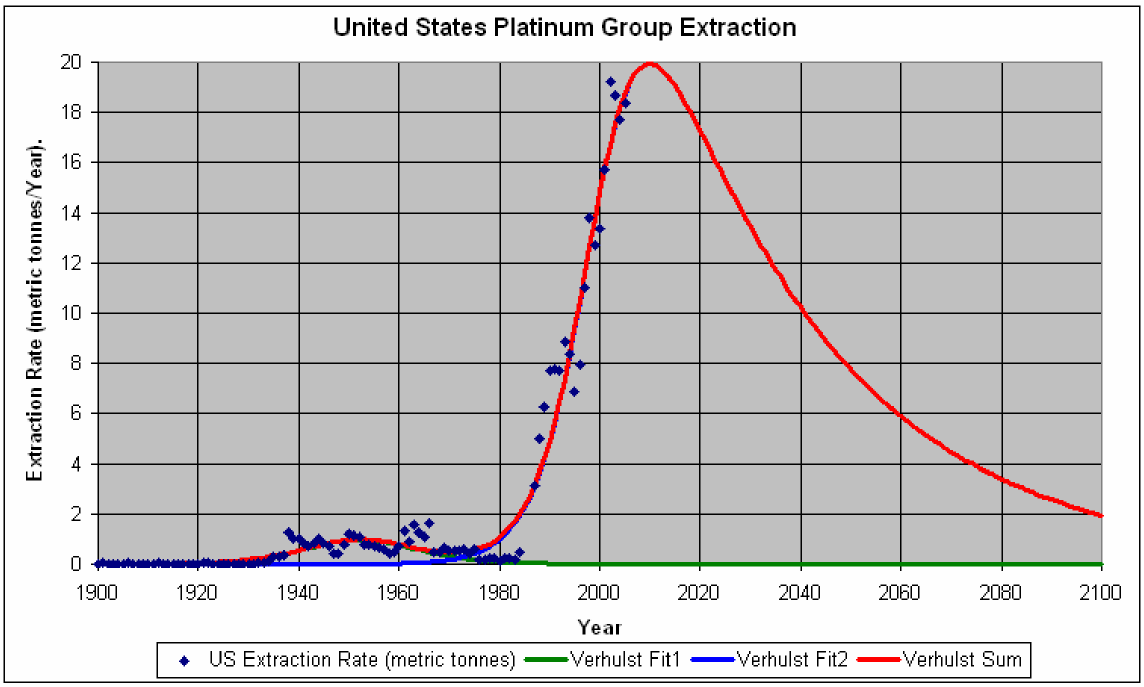

Figure 3-1. Double Verhulst function fit to the United States platinum-group extraction data.

The sum of the Qs ($Q_1 + Q_2$) for the two Verhulst functions is 1169 metric tonnes. The amount extracted by 2005 was 247 metric tonnes. The reserves plus the amount extracted is 1147 metric tonnes and the reserves base plus the amount extracted is 2247 metric tonnes. So the sum of the Qs is slightly larger than the reserves plus the amount extracted and smaller than the reserves base plus the amount extracted.

The recent large platinum-group peak since 1980 is due to the advent of the industry's massive use of platinum-group metals for catalysts for chemical reactions and for pollution-reduction devices for vehicles.

It is possible that will be other extraction peaks for the platinum-group metals.

World Platinum-Group Extraction

Figure 1-2 shows a double Verhulst-function fit (**Roper, 1976**) to the World gold extraction data with the following parameters:

World Parameters	
Q_1	5518 metric tonnes
T_1	1982 year
t_1	9.0 years
n_1	1
Q_2	43804 metric tonnes
T_2	2040 year
t_2	10.2 years
n_2	4.87

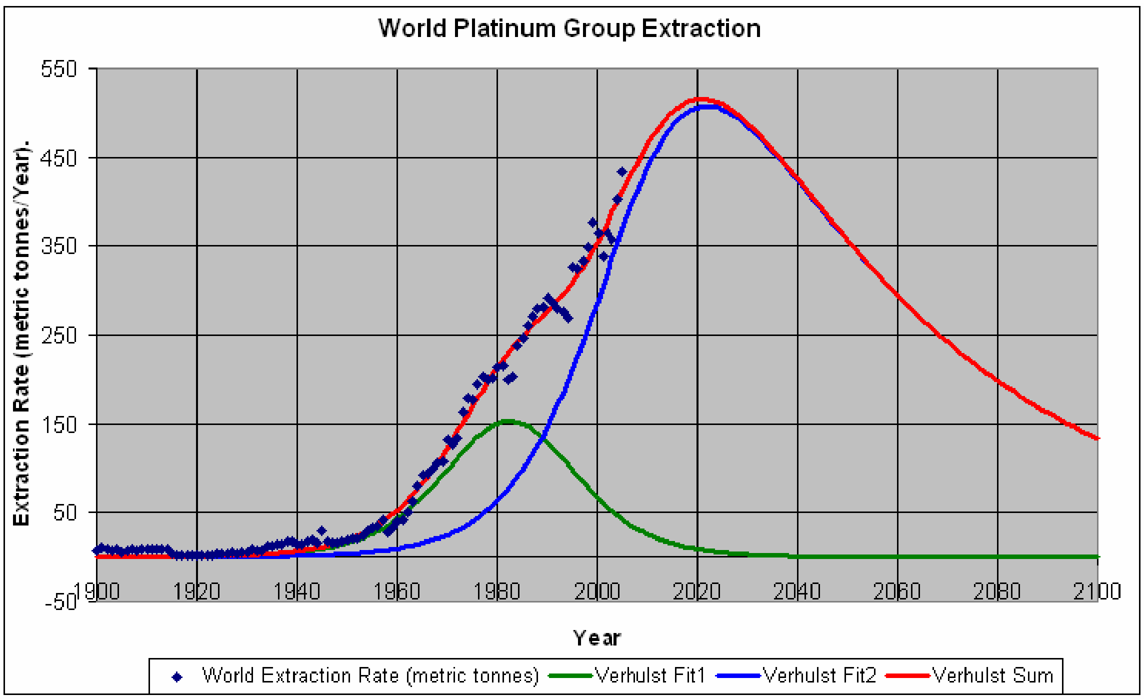

Figure 3-2. Double Verhulst function fit to the World platinum-group extraction data.

The sum of the Qs ($Q_1 + Q_2$) for the two Verhulst functions is 49322 metric tonnes. The amount extracted by 2005 was 11010 metric tonnes. The reserves plus the amount extracted is 82020 metric tonnes and the reserves base plus the amount extracted is 91020 metric tonnes. So the sum of the Qs is slightly less than half the reserves base plus the amount extracted.

The 1980 peak for World platinum-group was probably due to the fact that the United States extraction had declined after a small peak.

It appears that the World platinum group has a decade or more to go before peaking and there may be more peaks in the future.

Platinum-Group Price

Figure 3-3. compares the World silver extraction rate with the silver price in $ per troy ounces.

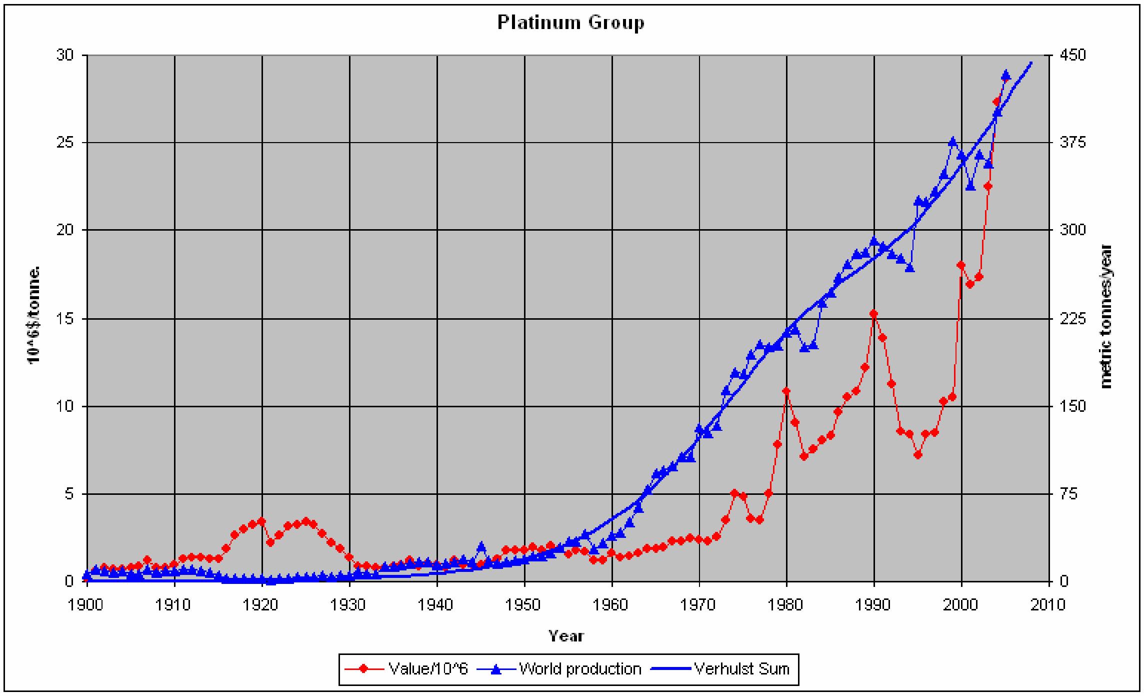

Figure 3-3. World platinum-group extraction rate in 10^6 troy ounces per year compared to platinum-group price in 10^6 $ per metric tonne.

I see no obvious correlation between the extraction rate and the price.

References

Roper, 1976: *Depletion Theory*, L. David Roper, http://arts.bev.net/RoperLDavid/minerals/DepletTh.htm . Also L. David Roper, Amer. J. Phys. 47, 467 (1979) and (**Bartlett, 2004**) p. 151.

Appendix 1. Definitions

The following two definitions are taken from http://minerals.usgs.gov/minerals/pubs/commodity/silver/silvemcs06.pdf .

Reserves Base: That part of an identified resource that meets specified minimum physical and chemical criteria related to current mining and production practices, including those for grade, quality, thickness, and depth. The reserve base is the in-place demonstrated (measured plus indicated) resource from which reserves are estimated. It may encompass those parts of the resources that have a reasonable potential for becoming economically available within planning horizons beyond those that assume proven technology and current economics. The reserves base includes those resources that are current economic (reserves), marginally economic (marginal reserves), and some of those that are current subeconomic (subeconomic resource). The "geologic reserve" has been applied by others generally to the reserve-base category, but it also may include the inferred-reserve-base category; it is not a part of this classification system.

Reserves: That part of the reserve base which could be economically extracted or produced at the time of determination. The term reserves need not signify that extraction facilities are in place and operative. Reserves include only recoverable materials; thus, terms such as "extractable reserves" and "recoverable reserves" are redundant and are not a part of this classification system.