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The Gold peak, easier to model than the oil peak?

Part 2

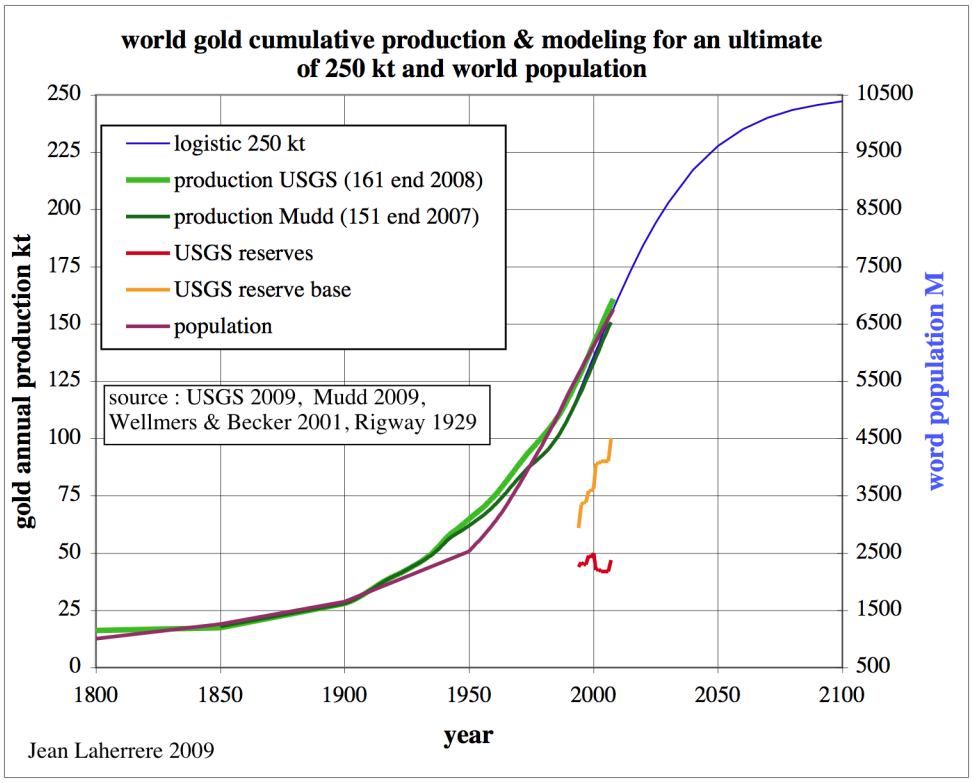
-Synthesis of main producers

The data from the above graphs on highest peak and year, annual and cumulative production for 2008, ultimate are gathered in the following table with the subtotal of these 14 producers and compared to the world production and ultimate.
These 14 producers gathers 80% of the world 2008 annual production (as cumulative production) and 66% of the world's ultimate value.

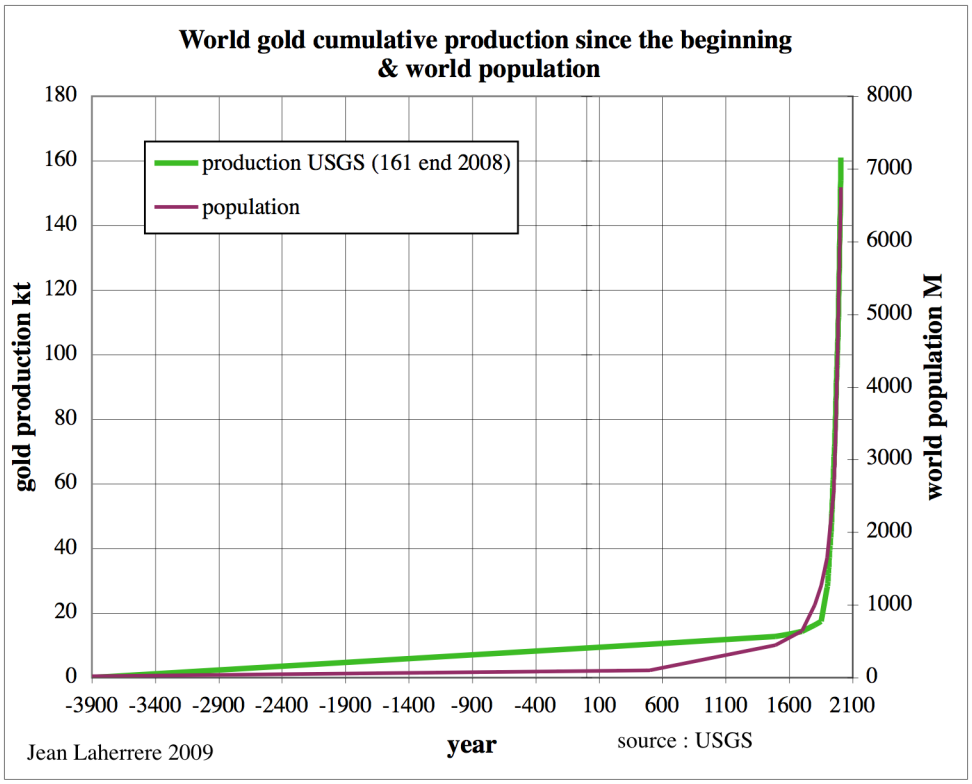
country	highest peak t/a	peak year	ap2008 t/a	CP2008 kt	U kt
S. Africa	1000	1970	234	52	58
Russia	220	1939	174	15	20
US	366	1998	230	17	20
Australia	309	1998	225	12	17
Canada	175	1991	100	10	12
China	288	2008	288	5	9
Indonesia	167	2005	90	1,9	4,5
Uzbekistan	100	1998	85	2,5	4,3
Brazil	105	1980	40	3,4	4
Peru	207	2005	175	2,6	4
Ghana	84	2008	84	1,9	4
Chile	54	2000	42	1	3,5
PNG	74	2000	65	1,6	3,5
Mexico	41	2008	41	0,6	2
subtotal			1873	127	166
world	2600	2001	2356	160	250

-World gold production

It was already mentioned the uncertainty of past data, in particular in countries of Former Soviet Union. Furthermore gold producers try to inflate their discoveries to get higher stock markets values, even to fraud. A series of high profile resource stock scams took place in the 1990s which culminated in the huge Bre-X scandal in 1995, when Bre-X's stock collapsed after its much-touted Busang gold project –thought at the time to contain more than 70-million ounces (2.1 kt) of gold- turned out to be a fraud; core samples from the drills had been tampered with and expertly "salted" with gold dust.
The world cumulative gold production has reached about 150 kt at end 2008 (151 kt for Gavin Mudd and 161 kt for USGS, which was too high for FSU) and USGS estimates gold remaining reserves at 50 kt and resources at 100 kt. We model the future for an ultimate of 250 kt.
The world population is also plotted and displays a good correlation with cumulative gold production.
Figure 51: world cumulative gold production & modelling for an ultimate of 250 kt

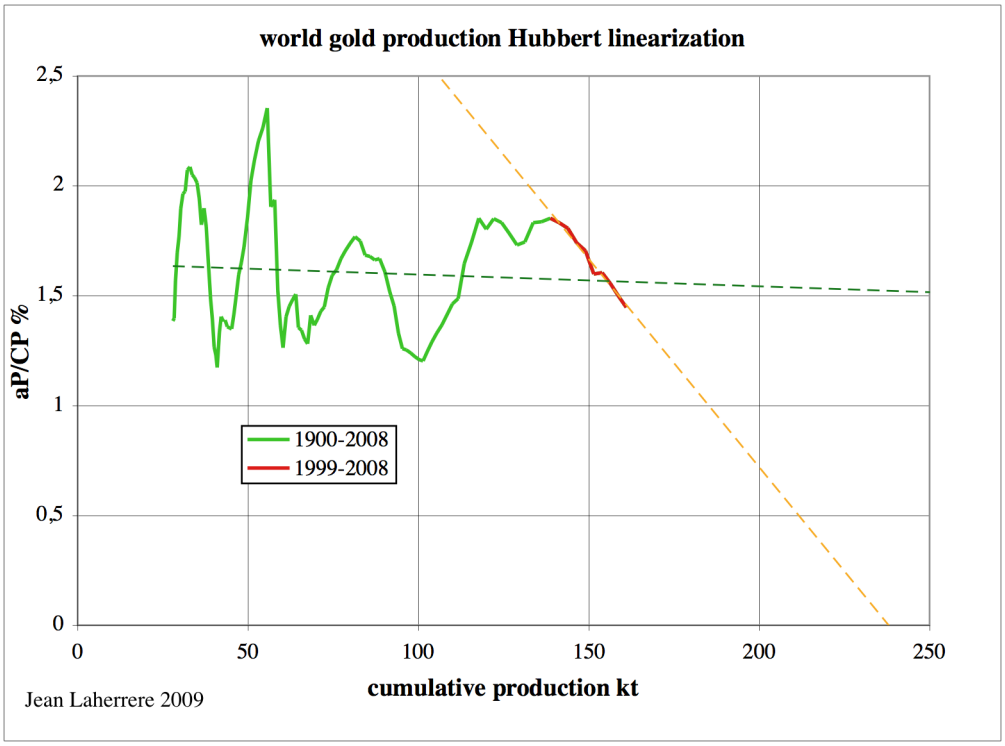


Gold production is reported to have started about 6000 years ago, but industrial production started around 1900. Gold cumulative production displays a real hockey stick!
Figure 52: world cumulative gold production since the beginning of gold discovery in -3900 and world population

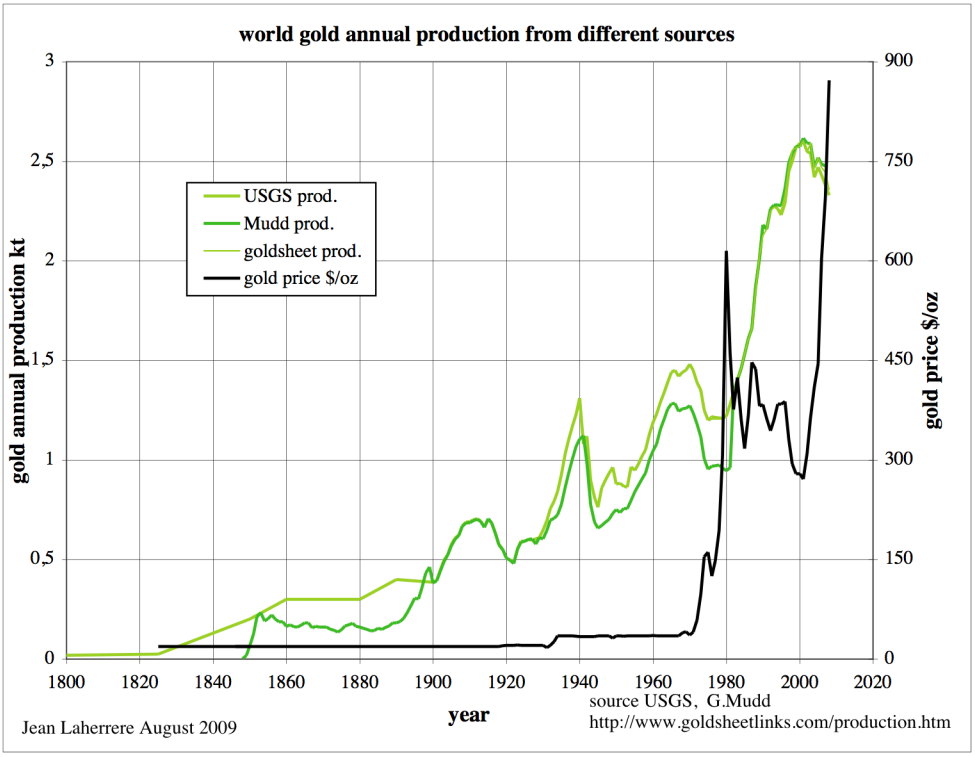


Hubbert linearization (annual production over cumulative production percentage versus cumulative production) is often used to estimate the ultimate with a linear extrapolation, but it only works if cumulative production follows a logistic curve (called S curve). The world linearization graph is

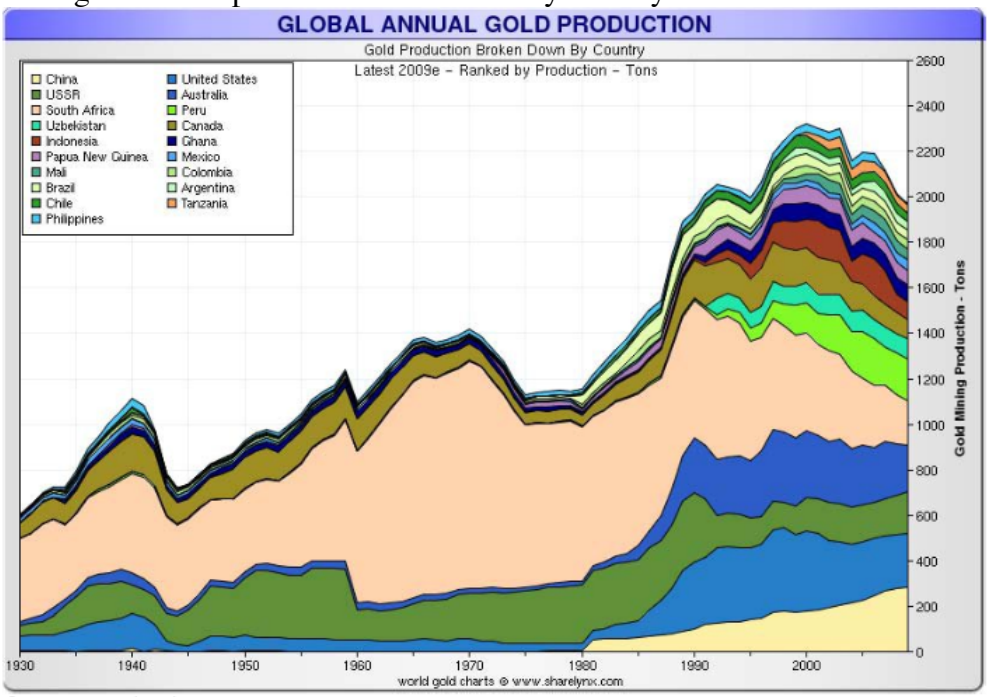
useless; no reliable linear extrapolation could be drawn, except that the last 10 years since 1998 could be extrapolated towards 240 kt.
Figure 53: world gold production Hubbert linearization



World gold annual production is plotted from different sources: USGS, Gavin Mudd, goldsheetlinks and there is a large discrepancy during the war and the cold war because of FSU overestimates by the CIA. Gold price is also plotted with the drastic increase of 1980 and 2008.
Gold annual production has peaked in 2000 and the decline is as steep as the increase despite the increase of gold price.
Figure 54: world gold annual production from different sources

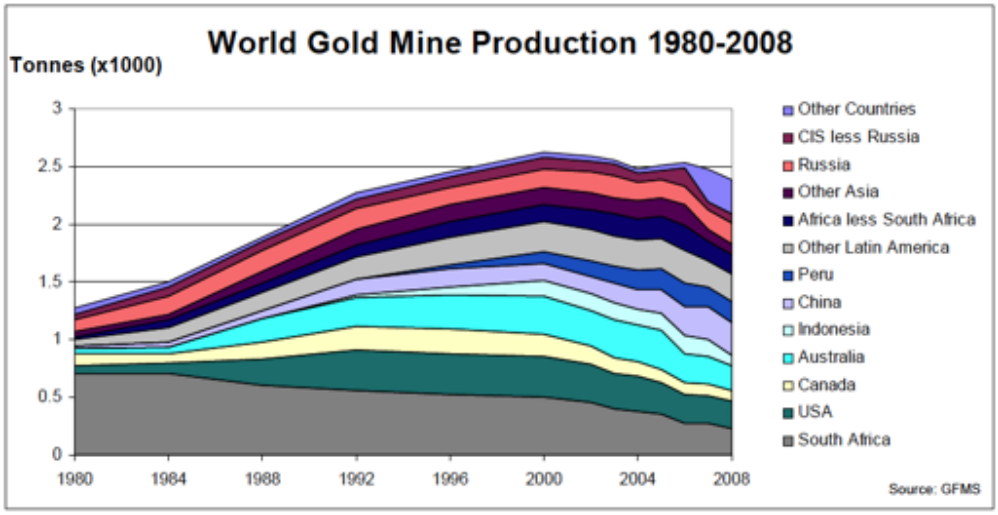


The breakdown by countries is well seen on the graph from the 2009 Erste Bank Special Report Gold, despite that the USSR collapse in 1960 is wrong as previously described.
Figure 55: world gold annual production breakdown by country 1930-2008

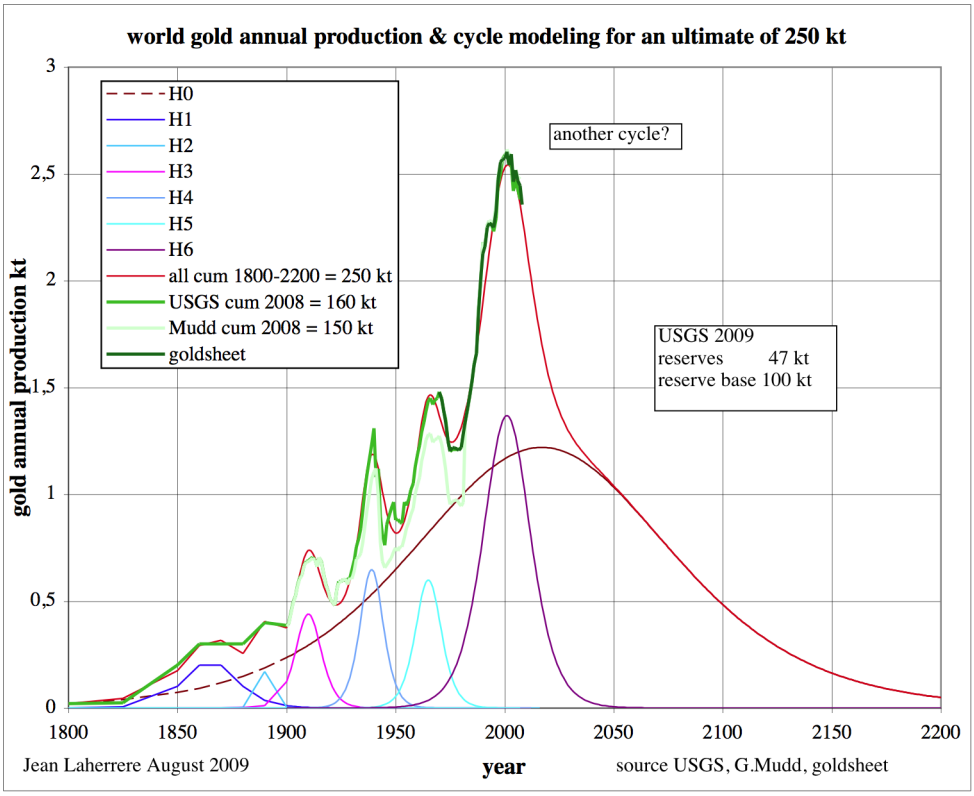


Source: www.sharelynx.com

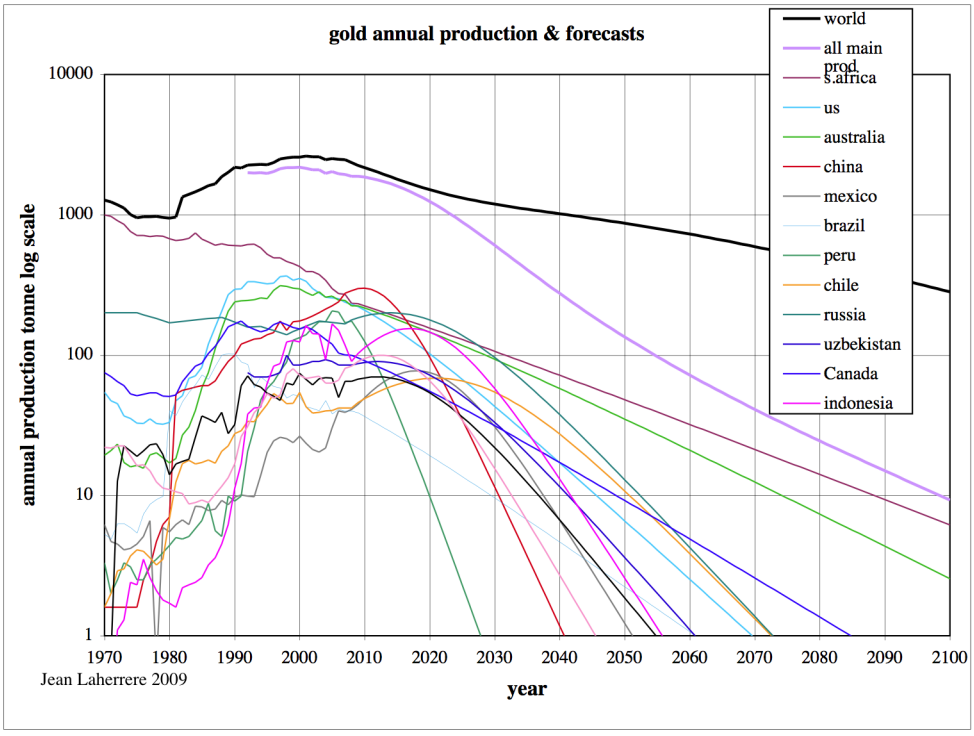
Moorhead 2009 Newcrest has a similar graph for 1980-2008
Figure 56: world gold annual production breakdown by country 1980-2008



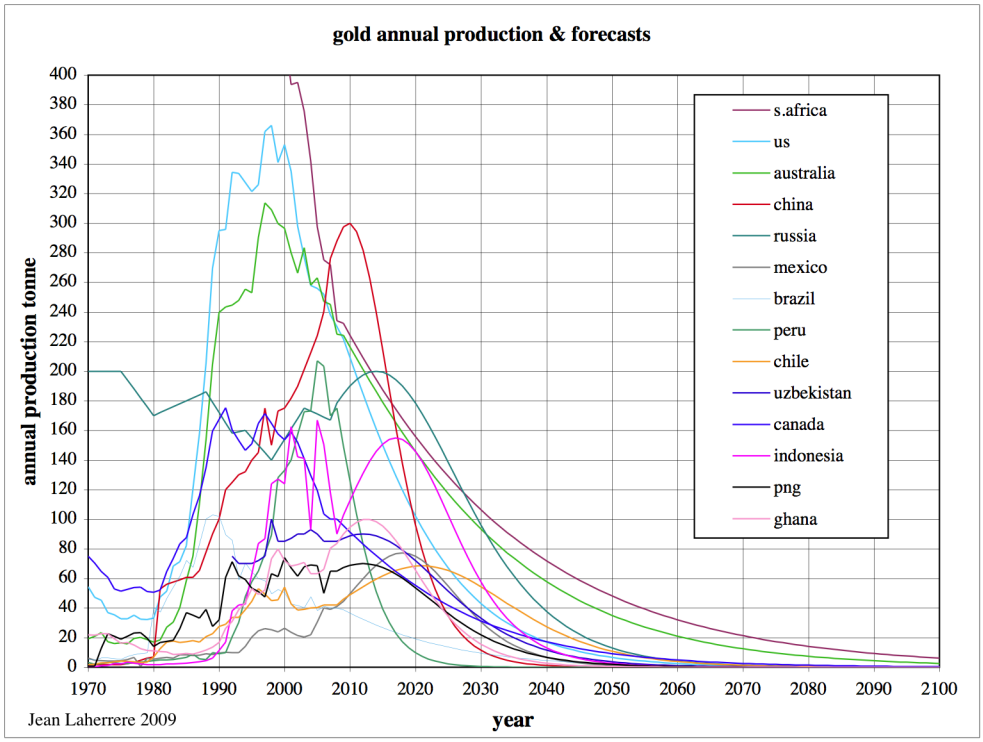
World annual gold production is modelled with 7 cycles, but from 1800 (close to zero) to 2000 peak the pattern looks like a simple bell-shape despite several short bumps.
Figure 57: world gold annual production & modelling for an ultimate of 250 kt



Gold annual production and forecasts of the main producers are compared.
If China is now the largest producer, South Africa could be back in 2030 if its 58 kt ultimate is right. New producers will arrive if the world ultimate at 250 kt is right.
Figure 58: gold annual production of the main producers in log scale



The same graph in normal scale:
Figure 59: gold annual production of the main producers



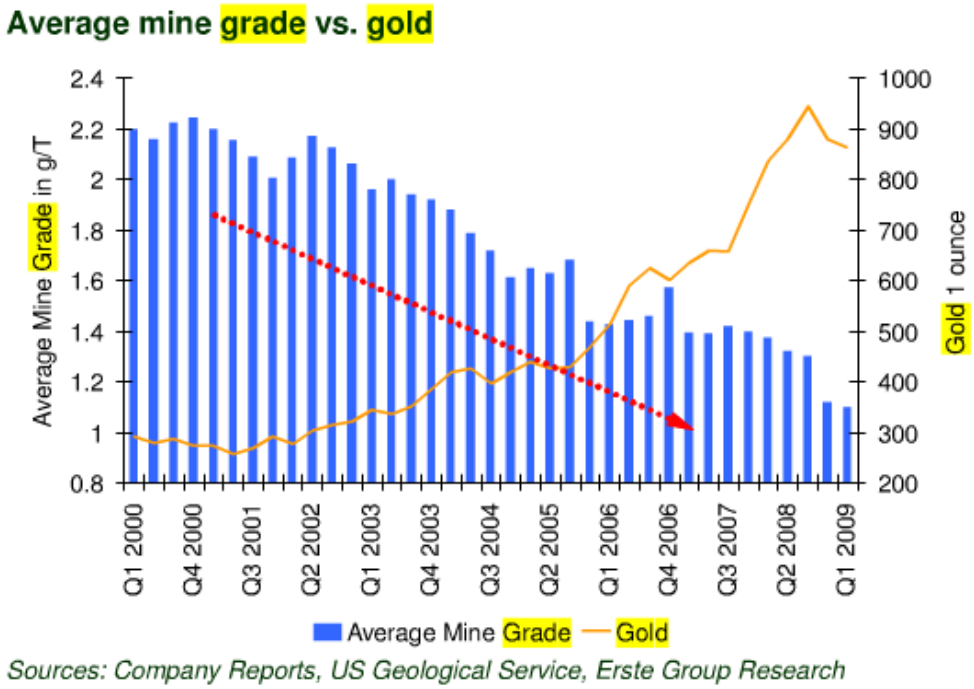
-**World gold grade**

It is very hard to find historical data on world gold mine grade. The best one I found is from 2009-07-02 Erste Bank Special Report GOLD

http://www.scribd.com/doc/17176164/20090702-Erste-Bank-Special-Report-GOLD1

The graph starts in 2000 at 2.2 g/t and declines down to 1.1 g/t in the first quarter of 2009. It is confirmed by data from CIBC World Markets.

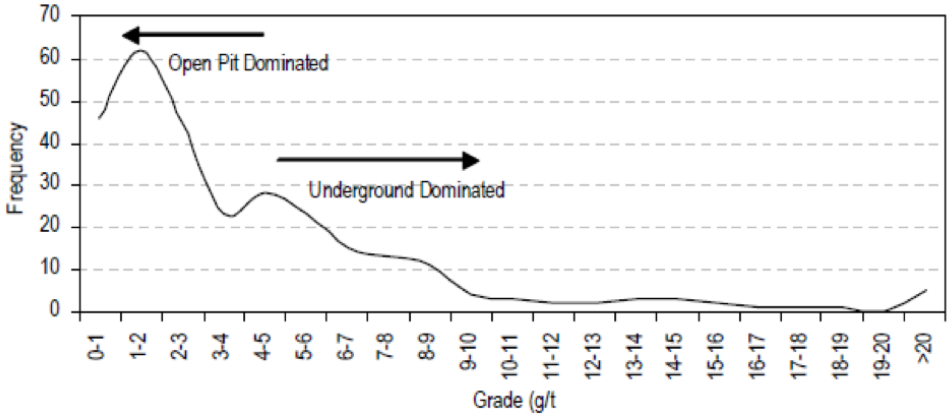
Figure 60: world gold mine grade 2000-2009



Estimation of reserves needs to assume an economical cutoff, which mainly depends upon the gold price and the mine set up (surface or deep mine).

Gold cutoff was taken as 1 g/t a few years ago, but with the recent gold price increase it went down to 0.7 t/g and now to 0.5 g/t.

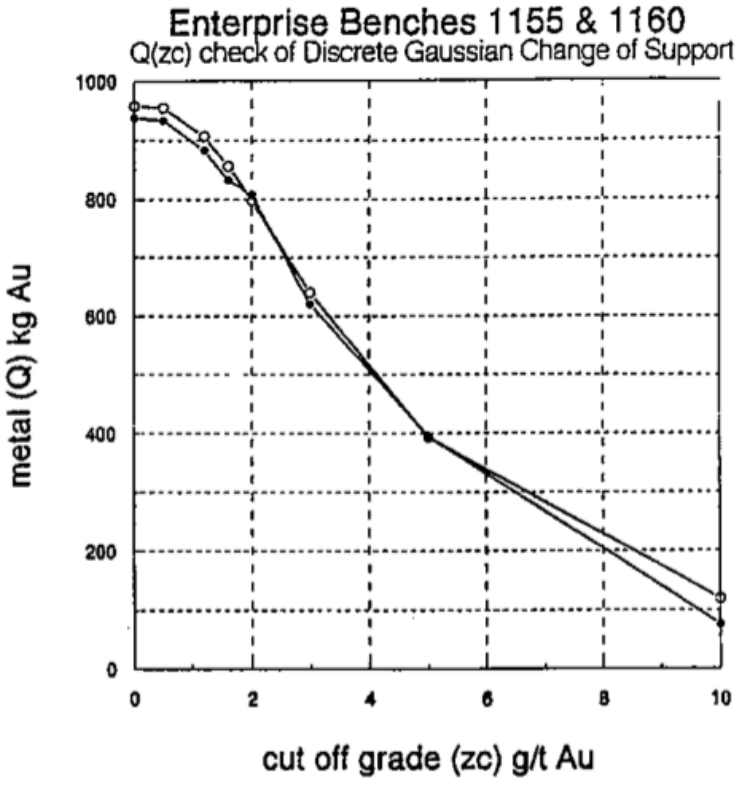
But in fact there is a little difference in reserves volume between cutoff at 0.5 g/t or 1 g/t, because the frequency of gold grade displays a pattern where 1-2 g/t seems more frequent than 0-1 g/t , as shown in this graph by Andean Resources Ltd
(http://www.andean.com.au/pdf/presentations/2009/Andean_Presentation_May_09.pdf)
Figure 61: gold grade frequency by Andean Resources Ltd



•Grade determines operating costs on a per ounce basis
•Provides cushion for safety
•Market will pay for uniqueness and gold deposits show a lognormal distribution when it comes to grade richness

Source: Barry Cooper, CIBC World Markets and Company Reports

This graph surprises me because it is against most fractal distributions I have seen. The frequency must be computed with the number of deposits and not by the volume, and, of course, low-grade deposits are ignored; as well as gold in seawater.
Vann et al 1995 « *Global resource estimation* »
http://www.qgeoscience.com/images/downloads/Vann%20and%20Sans%20DG%20Enterprise.pdf has estimated the reserves for a particular deposit when the f difference between 1 g/t and 0 g/t is small
Figure 62: gold volume estimate versus gold grade frequency (Vann 1995)



-Gold in seawater

Everyone agrees that gold in seawater represents a huge volume, but it is hard to get a consensus on the concentration (grade) and volume. The volume of oceans is 1.3-1.5 billion km3 (10E18).

The famous chemist *Fritz Haber had heard that a ton of seawater contained 5/1000ths of a gram of gold or even more which meant the oceans could contain something like 8 million tons of it. Early sample tests were encouraging but not conclusive so they took about 5000 samples back to his Berlin laboratory. Alas the final result was that a ton of seawater only contained about 1/5000th of a gram. This was way too low to make it economically feasible to extract the gold. It was a crushing blow for Haber.* (http://www.beadinggem.com/2008/06/man-who-tried-to-extract-gold-from.html)

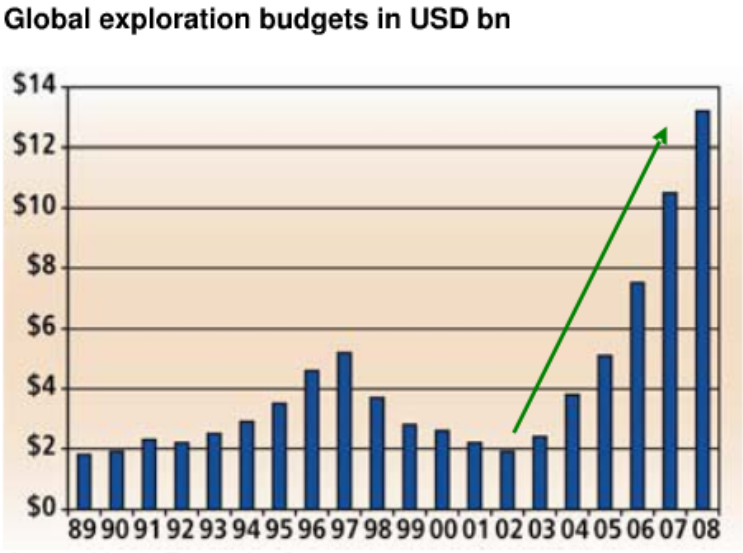
	Concentration 10E-12	volume kt	reserves kt
-Haber	200	320	
-Bardi & Pagani 2007 (TOD 4558)	11	14 300	42
-Dartmouth University	600	8 000	
- http://encarta.msn.com/text_761570498__1/gold.html	50 000	9 000 000	
- http://goldfever.com/gold_sea.htm	10	750	

It is a mess!

-World gold exploration and budgets

In the Erste 2009 report, it is interesting to see that gold exploration budgets have sharply increased since 2003, but 2009 is estimated to be down by 40%!

Figure 63: gold exploration budgets from Erste report

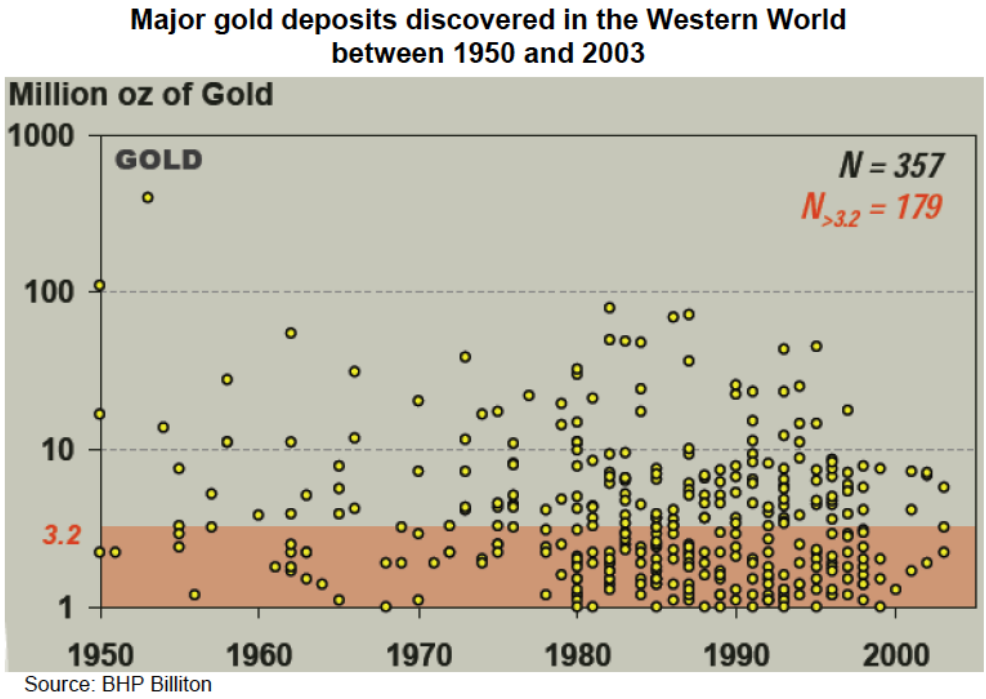


Source: Metals Economics Group

[6] http://www.metalseconomics.com/pdf/Strategies_for_Gold_Reserves_Replacement_2009.pdf

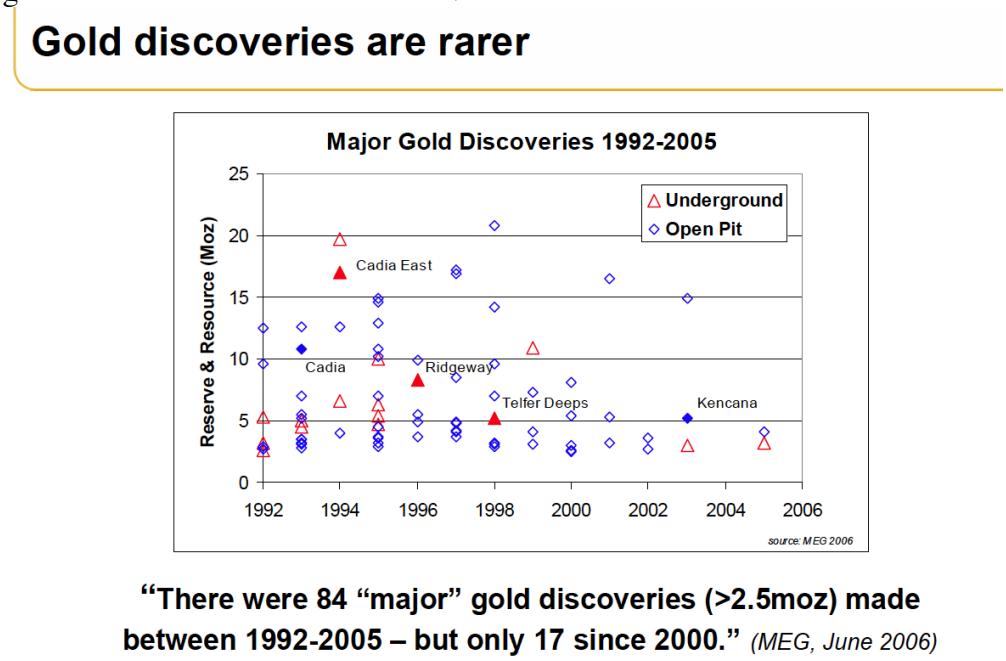
The discoveries in the western world (Owen Hegarty CEO G-Resources «*Gold: the perfect metal*» June 2009) peaked around the 1980s but low discoveries around 2000 may be due to low exploration investments.

Figure 64: gold discoveries in the western world 1950-2003

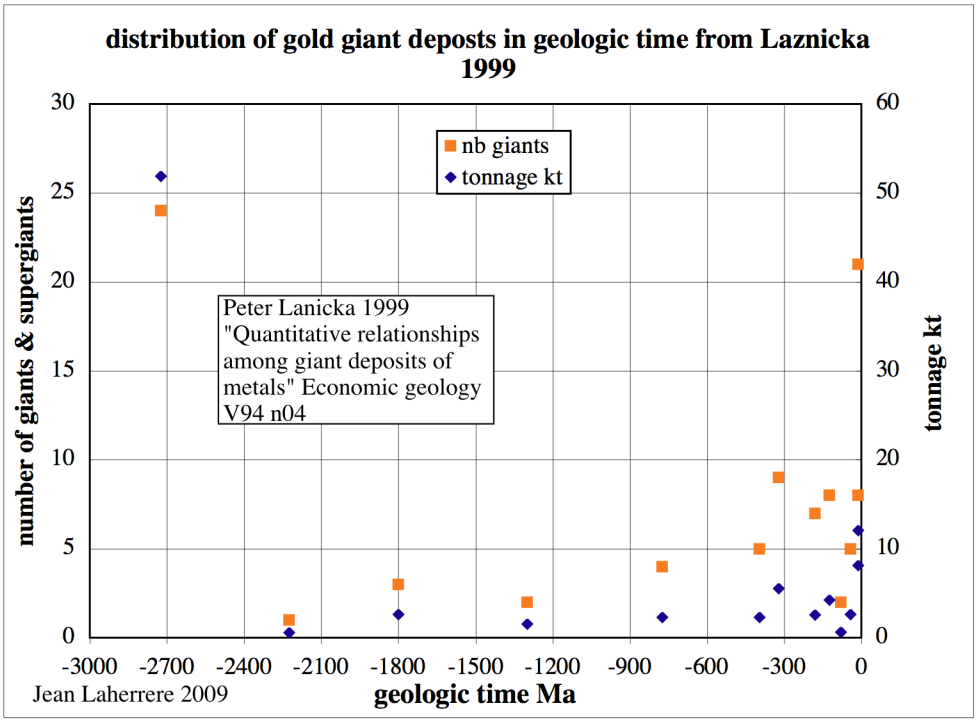


The Metals Economic Group says there were only been four world-class gold discoveries in the last 15 years. In fact, of all new discoveries, 75 % are made by the juniors,
(http://www.commodityonline.com/news/Peak-Gold-Yellow-Metal-reserves-are-depleting-14753-3-1.html)

Newcrest (http://www.mineprofs.org/info/annual_meetings/2009/SOMP-09-General-Moorhead.pdf) states that gold discoveries are rarer:
Figure 65: gold discoveries 1992-2005 from Newcrest



-gold deposits distribution
Peter Laznicka 1999 "*Quantitative relationships among giant deposits of metals*" Economic geology V94 n04 gives the gold distribution from geological ages
Figure 66: gold giant deposits (number & tonnage) in geologic time from Laznicka



Laznicka has listed over 500 giant metal accumulations in a database GIANTDEP that is not available on the web.

Robinson 2007 «*The Spatial and Temporal Distribution of the Metal Mineralisation in Eastern Australia and the Relationship of the Observed Patterns to Giant Ore Deposits* » (http://espace.library.uq.edu.au/eserv/UQ:107702/ljr_phd_8_07a.pdf) has a similar graph slightly different despite being from the same source

Figure 67: number of gold giant deposits in geologic time from Robinson page 220

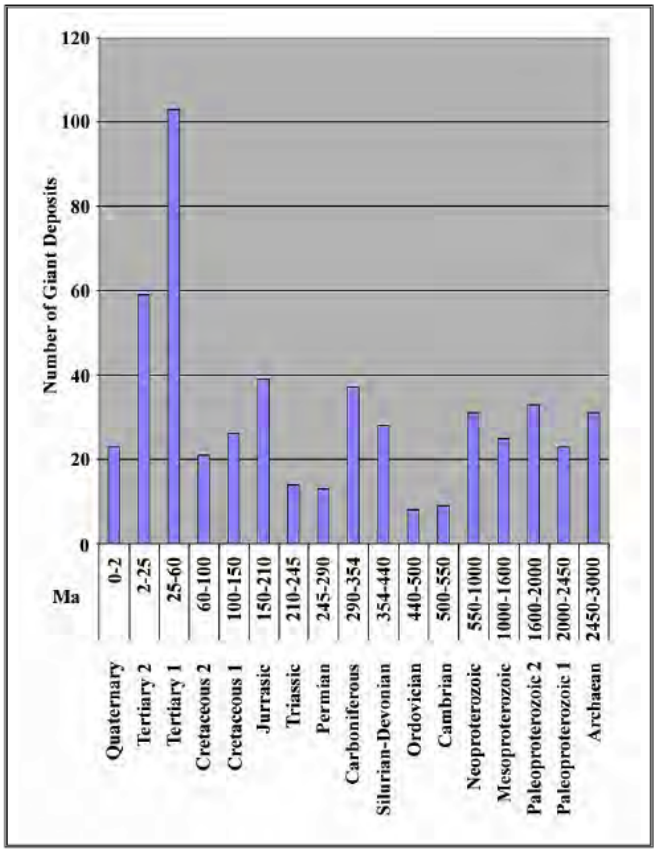


Figure 6-29 Giant Ore Deposits in Geological Time

Figure 68: number of gold giant deposits in geologic time from Robinson page 221

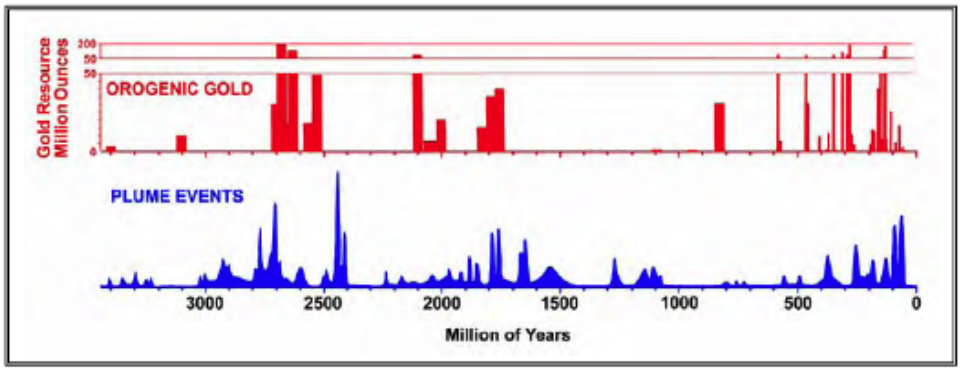


Figure 6-30 Temporal Distribution of Orogenic Gold Deposits and Plume Events

After Groves (2005), Abbott and Isley (2002b) and Goldfarb et al., 2001

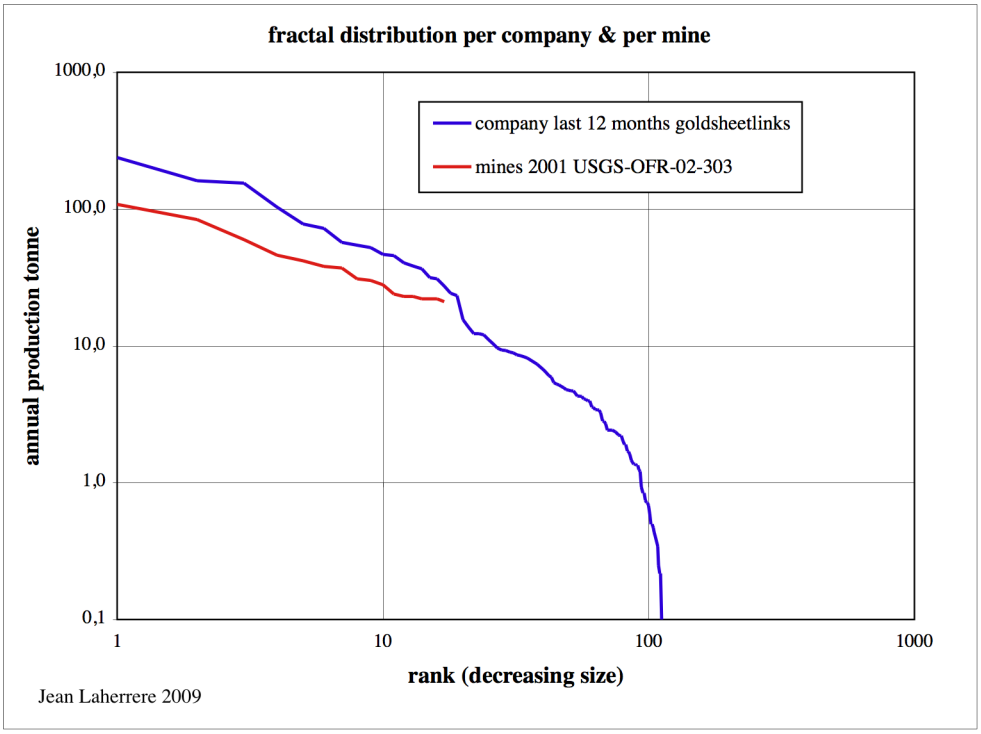
Laznicka 's classification is 4 kt for a supergiant, 400 t for giant and 40 t for large deposit.
Figure 69: classification of gold deposit Robinson page 89

Table 3-1 Classification Scheme for Large, Giant and Supergiant Deposits

After Laznicka (1998)

		Minimum Tonnage of Metal		
Metal	Clarke (ppm)	Large Deposits	Giant Deposits	Supergiant
Zn	70	700,000 t	7 Mt	70 Mt
Cu	55	550, 000 t	5.5 Mt	55 Mt
Pb	12.5	125, 000 t	1.25 Mt	12.5 Mt
U	2.7	27,000 t	270,000 t	2.7 Mt
Ag	70 ppb	700 t	7, 000 t	70,000 t
Au	4 ppb	40 t	400 t	4000 t

Unfortunately no complete list of world gold deposit reserves is available on the web. We have to restrict to deposit production.
The fractal distribution of gold deposits annual production (deposit size versus rank of deposit in decreasing size order) is plotted from USGS 0FR 02 303 table 11 world's largest mines in 2001 and gold producers from gooldsheetlinks. The fractal distribution is parabolic like all natural objects (Laherrere 1996, Laherrere & Sornette 1998)
Figure 70: fractal distribution of annual production per company & per mine

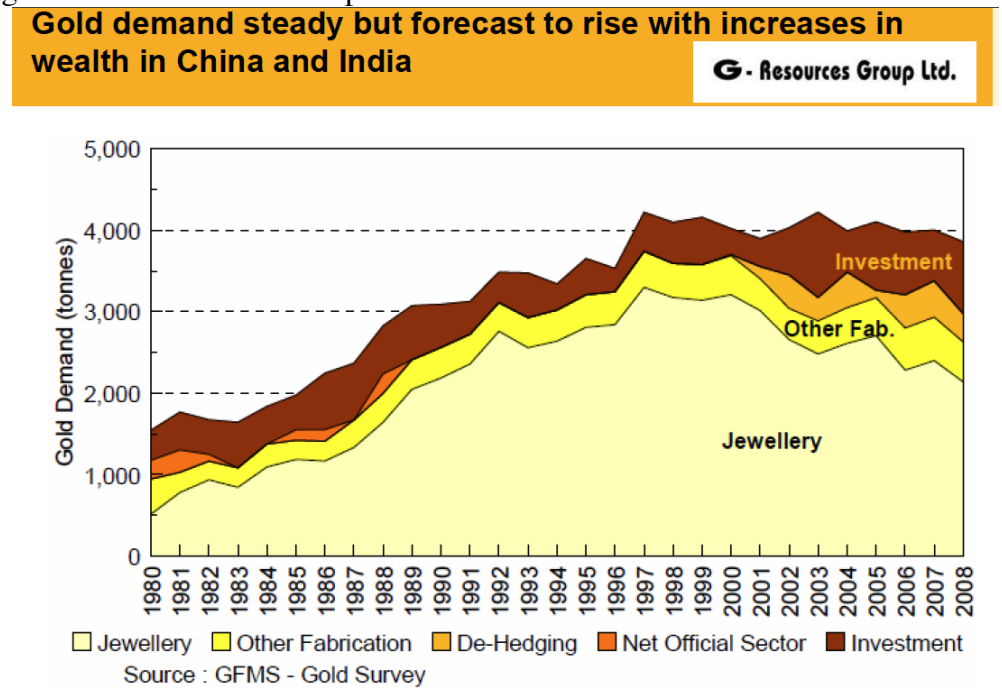


Fractal distribution is connected to Pareto's law: 80/20 (80% of the production comes from 20% of producers). The production of the 15 largest producers represents 51% world production (goldsheetlinks rank per company for the last 12-month trailing production August 2009 http://www.goldsheetlinks.com/ptable.htm)

-**World gold demand**

Contrary to oil, gold is mostly conserved, and demand can be much larger than mine production. The demand is mainly jewellery

Figure 71: gold demand from Erste report



The gold consumption pattern in 1999 (USGS –OFR-02-303-gold) shows that jewellery is the first use, followed by electronics, then coin

Figure 72: gold consumption pattern in 1999

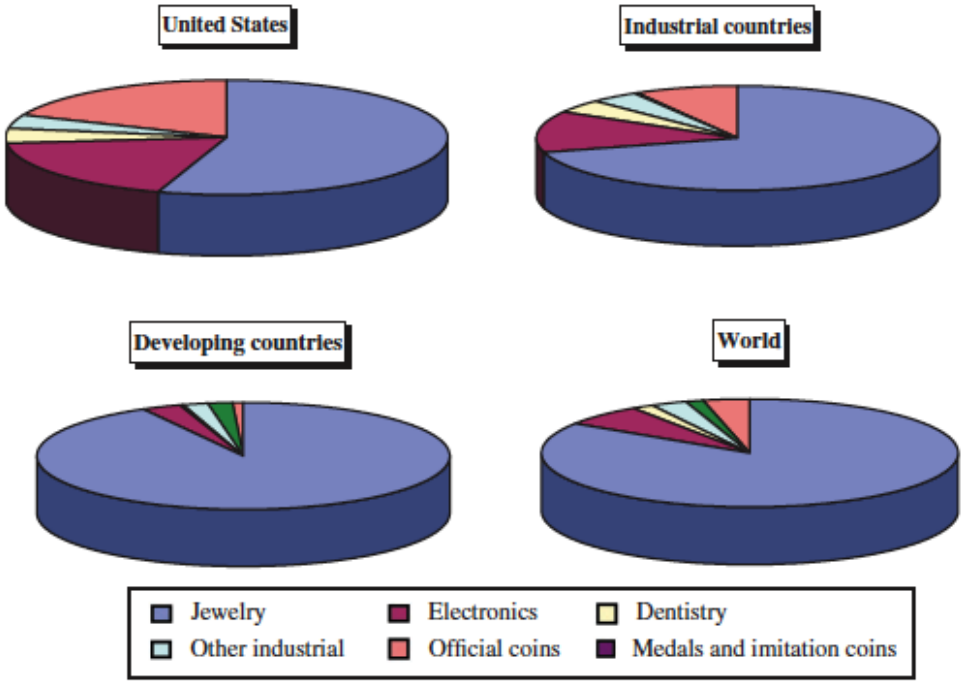
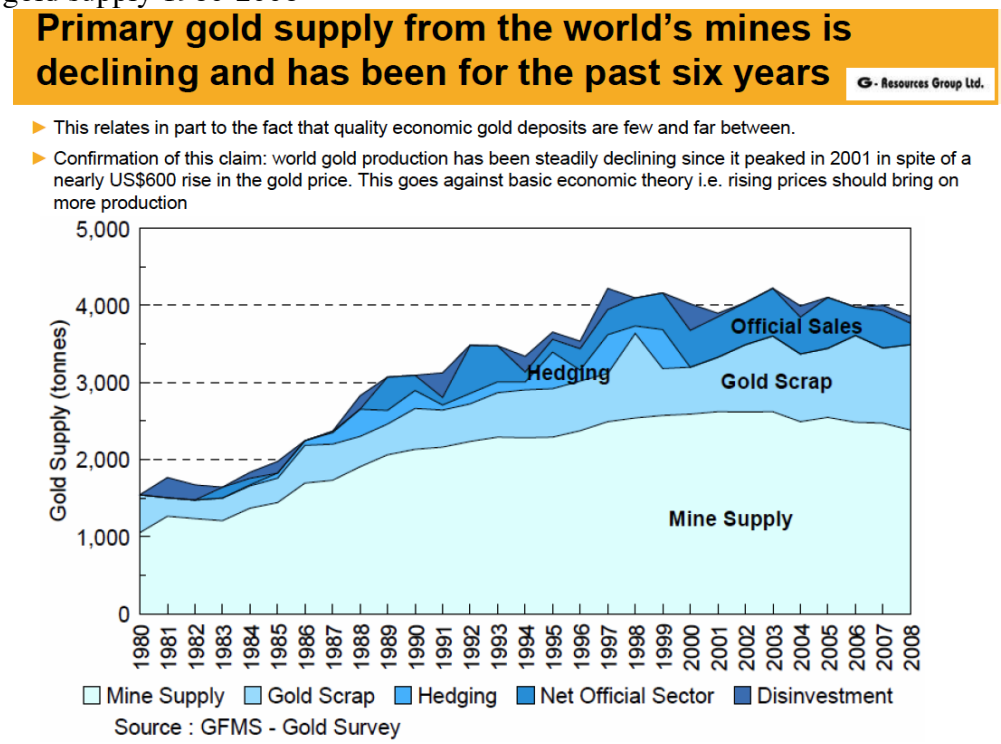


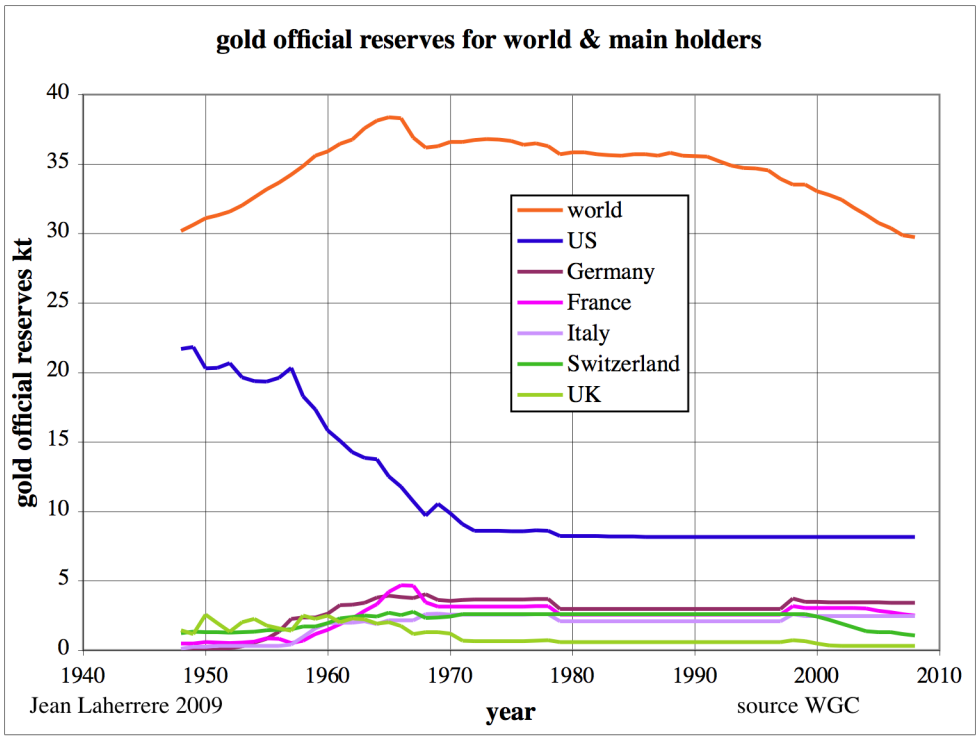
Figure 12. Gold consumption patterns in 1999. Data from U.S. Geological Survey, 1999; G

Mine supply provides the majority of gold supply, followed by gold scrap and sales.
Figure 73: gold supply 1980-2008



-Gold official reserves

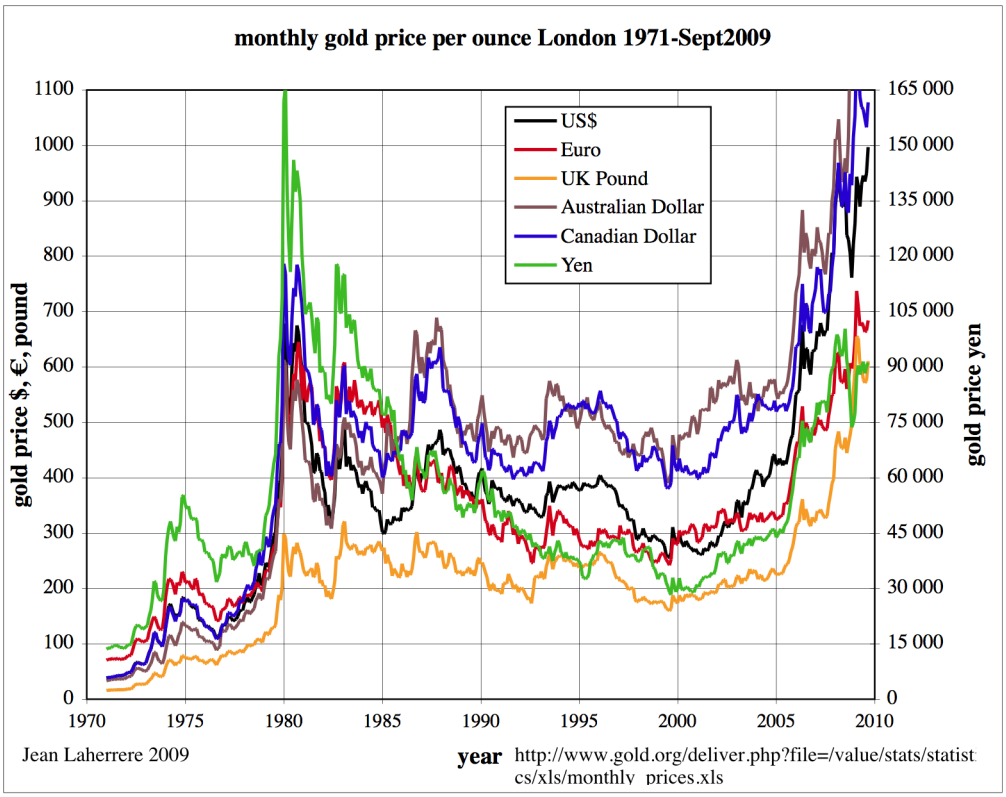
Gold reserves can either correspond to what is expected, from geological estimates, to be produced in mines, or the amount of gold in banks.
Figure 74: world gold official « reserves » and for main holders



-Gold price

Gold price (*London pm fix*) is displayed monthly in different currencies

Figure 75: monthly gold price in different currencies 1971-2009



Gold price is compared to oil price and wheat price in nominal dollar value. Gold price is following oil price, when wheat (which depends on oil for fertilizers, pesticide and machinery) price, which was very close to oil before 1973, is much less connected afterward.

Figure 76: gold, oil and wheat nominal price 1900-2008

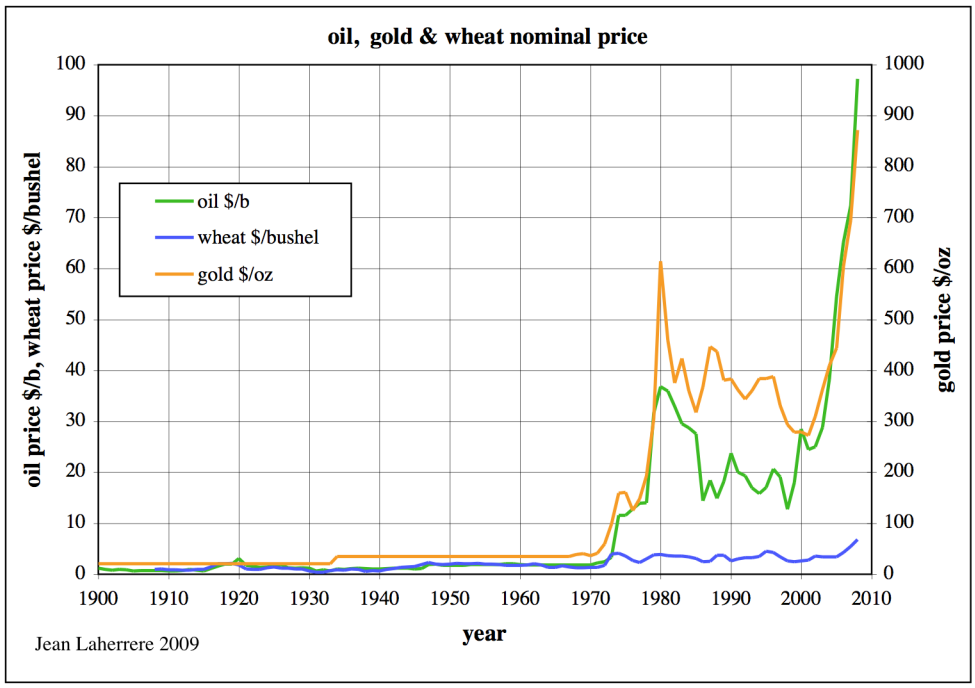
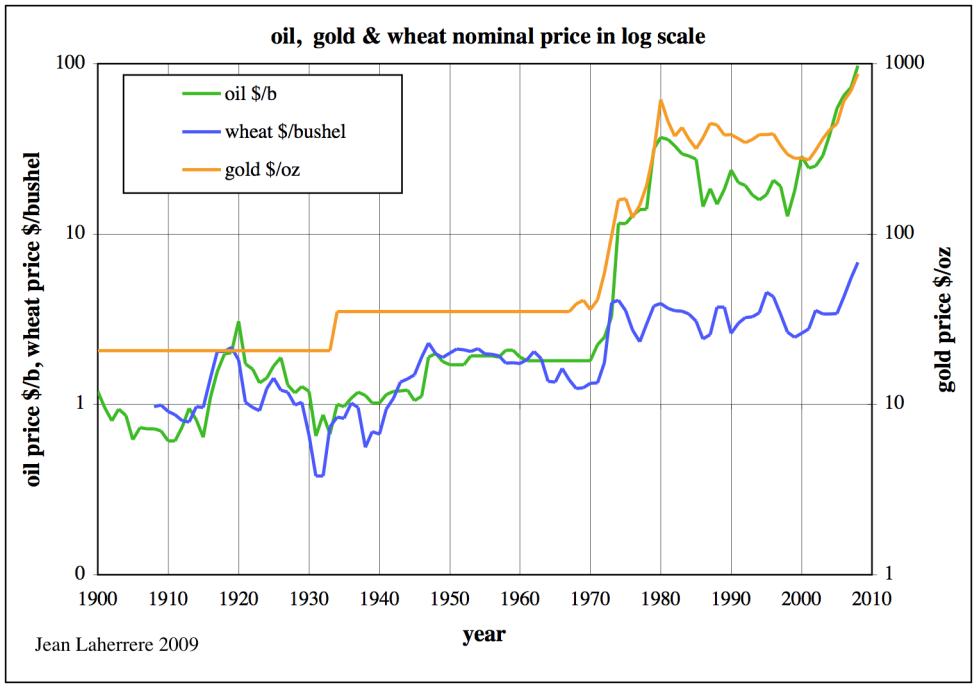
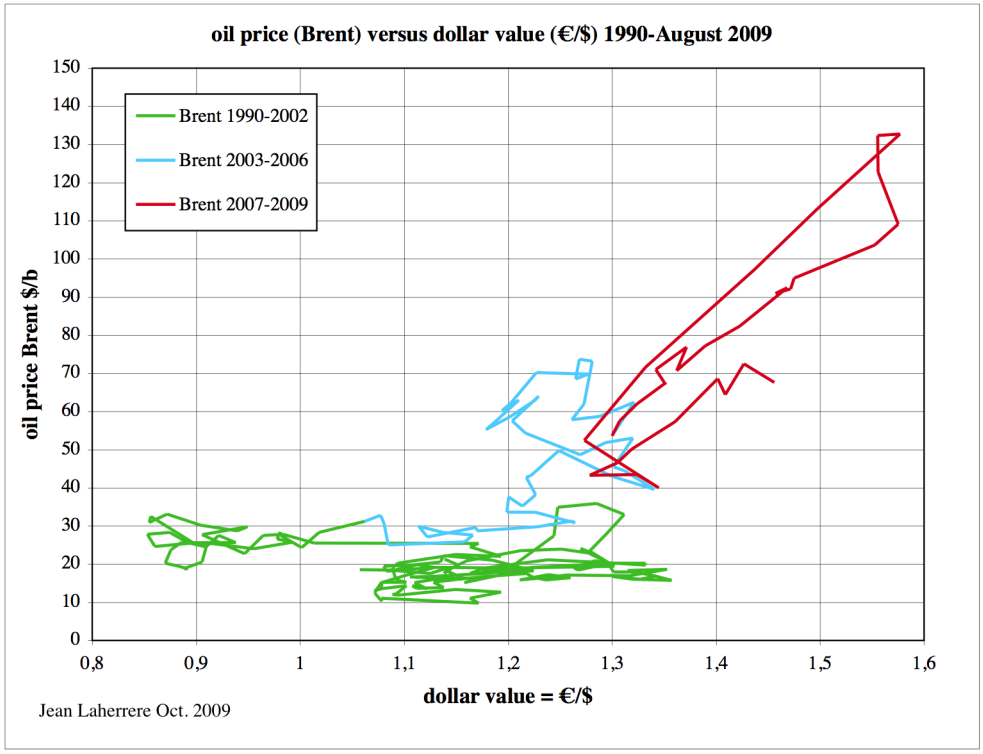


Figure 77: gold, oil and wheat nominal price 1900-2008 in log scale

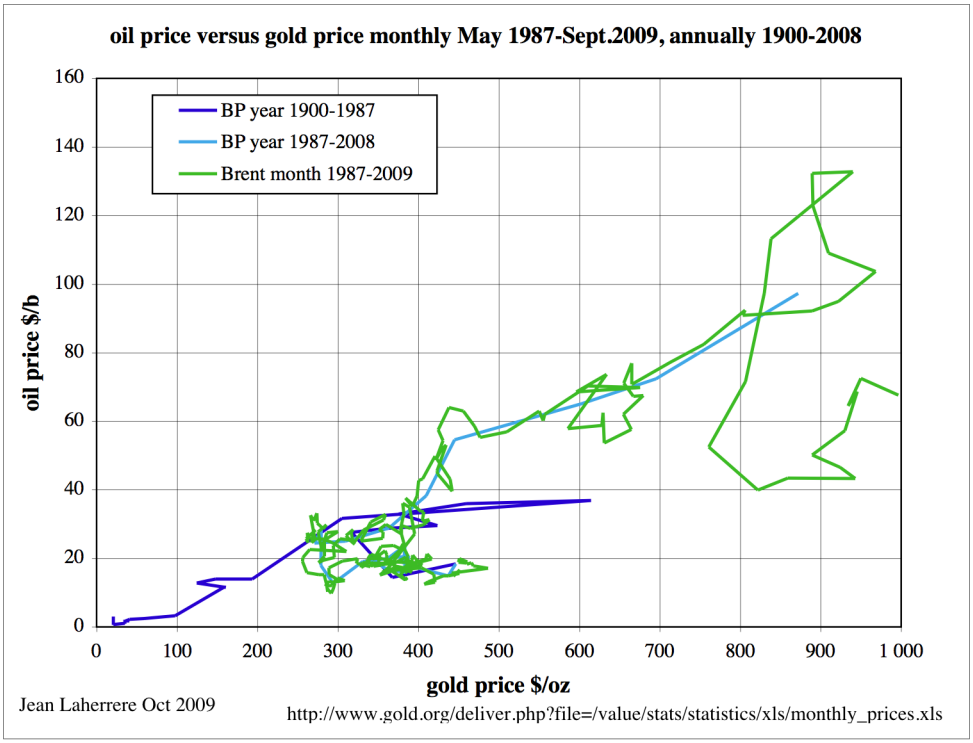


Oil price seems to depend, since 2007, upon dollar value:
Figure 78: oil price versus dollar value

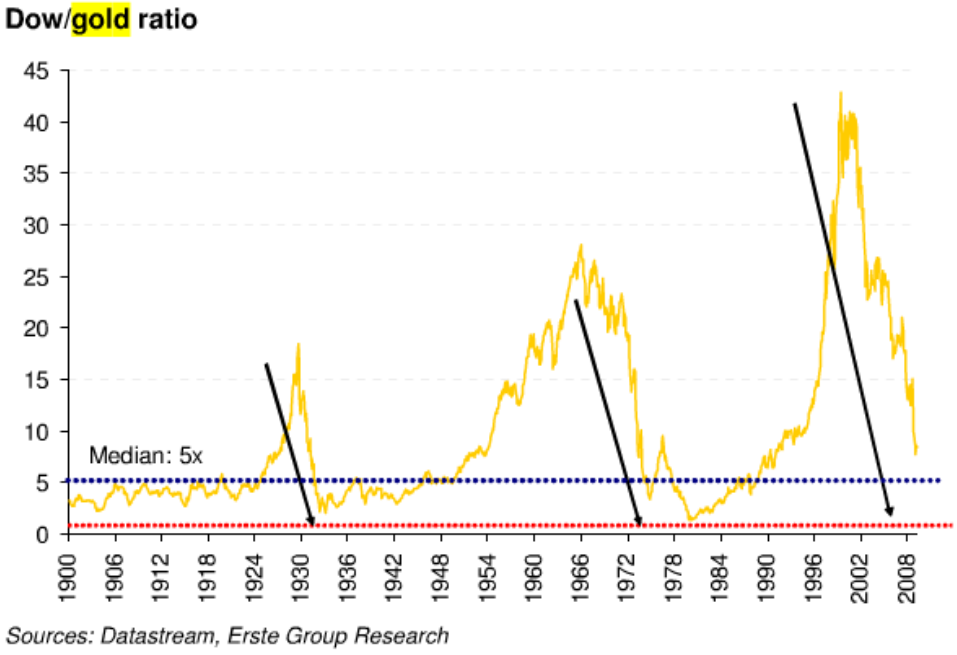


Oil price seems to depend on gold prize since 2000 except during the 1979-2000 period:
Figure 79: annual oil price versus gold price 1900-2008

But the monthly values for 2009 seems to get out of the previous trend: is it going to return?
Figure 80: annual oil price versus gold price 1900-2008, and monthly May1978-September 2009

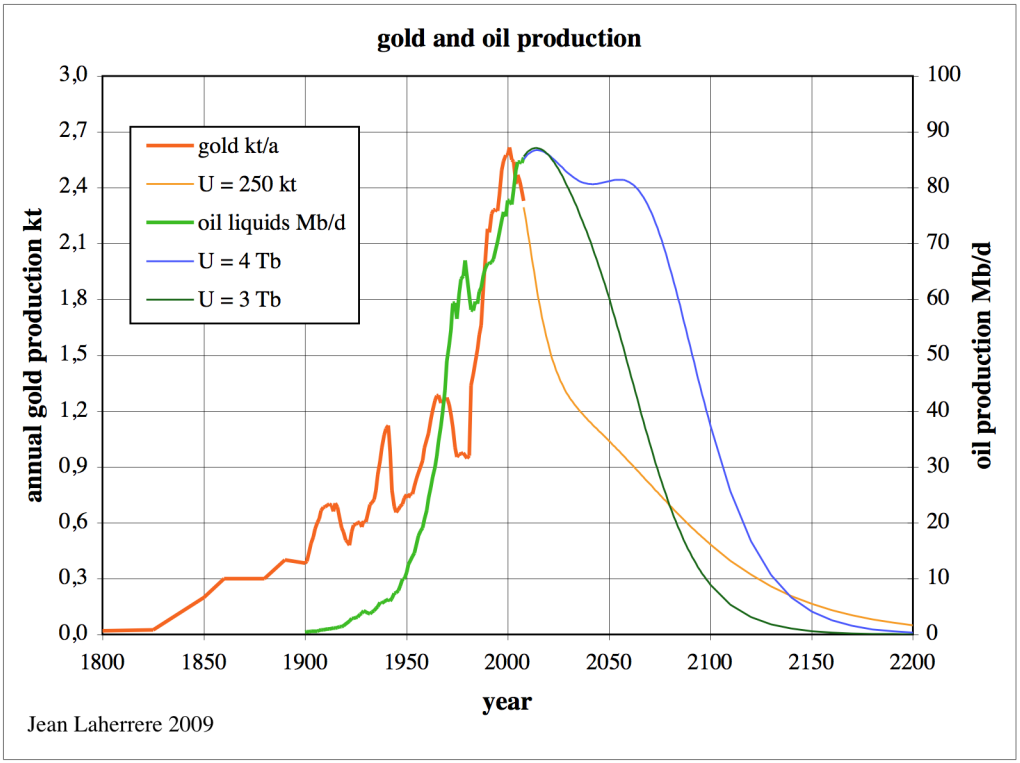


Erste Bank displays the gold over Dow ratio since 1900, with bursts and back to earth
Figure 81: Dow Jones value over gold price ratio 1900-2008



-Gold and oil annual production & forecast

The display of gold production & forecast for an ultimate of 250 kt is compared to oil (liquids) production & ultimates of 3 & 4 Tb.
Figure 82: gold and oil (liquids) production & forecasts 1800-2200



-Conclusions

Gold production has a more longer history than oil production, but both with a likely peak during this decade: 2001 for gold and 2008 for oil (in fact it is going to be a bumpy plateau instead of a peak), and they will cease to be extracted before 2200. Yet oil will be gone, converted into heat and ashes, when gold will remain as jewel and bullion.

Excluding soil and water, which allows us to grow our food, oil and gold must be the two most important minerals of our present civilization and their production would have spanned for only a few centuries, much shorter than western civilisation.

It is amazing to think that we are presently at a key time (peak or plateau) of our civilisation in term of supply and we do not realize it.

Paul Valery wrote in 1931 "*the time of a limited world begins*", but many do not accept this fact, wanting to keep consuming always more.

It is time to change our way of life.