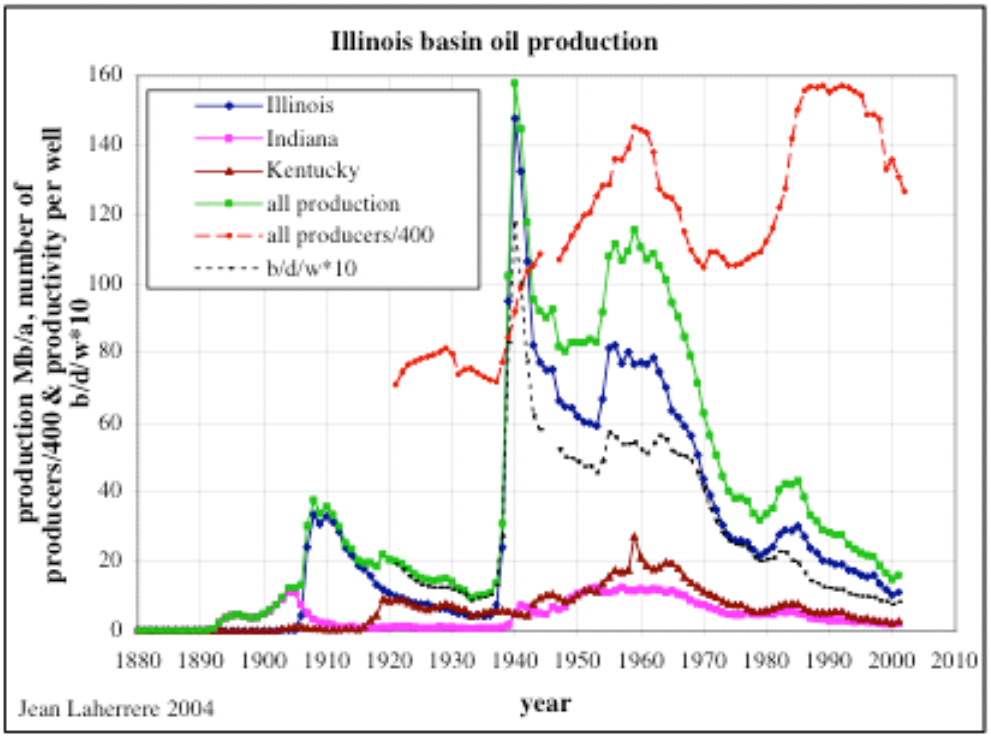
Comments on Hubbert's papers
By Jean Laherrere 21 November 2004

Introduction:
Comments on some papers sent by Chris Kuykendall by and about Dr. M. King Hubbert, mostly from Hubbert's archives at the American Heritage Center, University of Wyoming, in order to compare the strengths and weaknesses of Hubbert's work and theories.

-1- Hubbert 1956 « Nuclear energy and the fossil fuels » API San Antonio March
-1-1-Illinois
Hubbert describes two peaks in Illinois on figure 13 due to the two discovery cycles (first on surface mapping in 1905 and second on seismic in 1937), forecasting page 12 a third one because of new geological play, but a fourth one being unlikely.
He was right on the third one but wrong on the fourth.
Studying only state production is wrong, as it should be by basin
I plotted the Illinois basin adding to Illinois the Indiana and Kentucky production



This basin shows four production peaks: 1910, 1940, 1960 & 1985
It should be interesting to plot the annual backdated mean discovery but it seems impossible to get it on the web.
Plotting the total number of producers for the 3 States and the productivity per well indicates that the first 3 peaks were obviously from new play, when the 4th peak unforeseen by Hubbert seems to be more from an increase in wells due to high oil price.
From the last decade productivity and number of producers are falling, the basin is depleting fast.
-1-2: oil shales and tar sands page 19
Hubbert reports recoverable at 1000 Gb from oil shale in the US and 30à-500 Gb from the tarsands in Canada
He was too optimistic on the oil shales

-1-3: world coal page 21
He reports world recoverable coal at 2600 Gt (USGS) with a peak on figure 18 at 2150
In my paper HEC MBA Sept. 2004 (www.oilcrisis.com) I model coal with two ultimate peaking (450 Gtoe and 600 Gtoe or about 1000 Gt) around 2050
–1-4: world oil
He reports an oil ultimate of 1250 Gb (Weeks) peaking figure 20 at 2000 at 12.5 Gb/a but real production in 2000 was the double. He missed the relative first peak of 1979,as it came from high price and demand fall. His ultimate is quite too short.

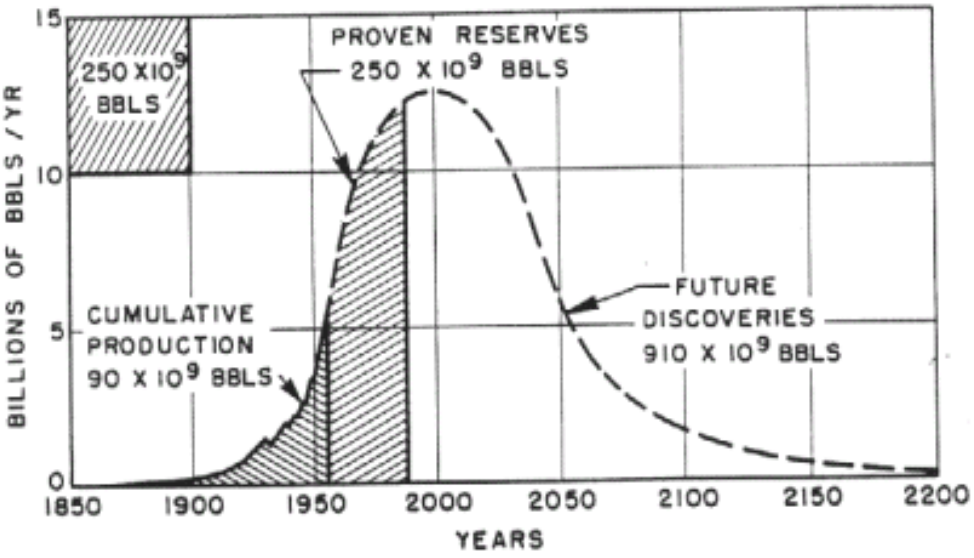


Figure 20 – Ultimate world crude-oil production based upon initial reserves of 1250 billion barrels.

-1-5: US NG
He reports figure 22 for an ultimate of 850 Tcf (Pratt 1961) a peak at 1970 at 14 Tcf/a dropping to 8 Tcf/a in 2000. Real production (dry) was 19 Tcf/a in 2000

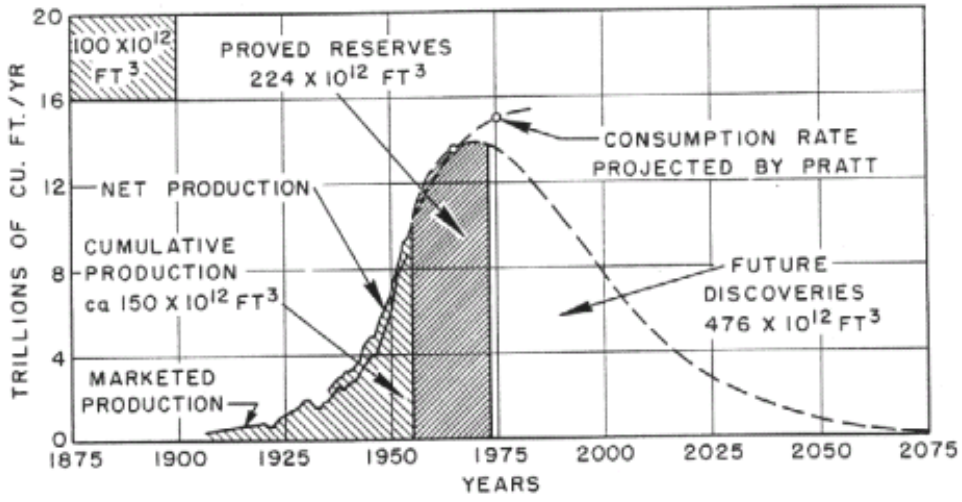


Figure 22 – Ultimate United States production of natural gas based upon initial reserves of 850 trillion cubic feet (after Pratt, 1956).

-1-6: Texas oil

Hubbert reports figure 23, for an ultimate of 60 Gb, a peak in 1965 at 1,2 Gb/a dropping to 0.2 Gb/a in 2000.

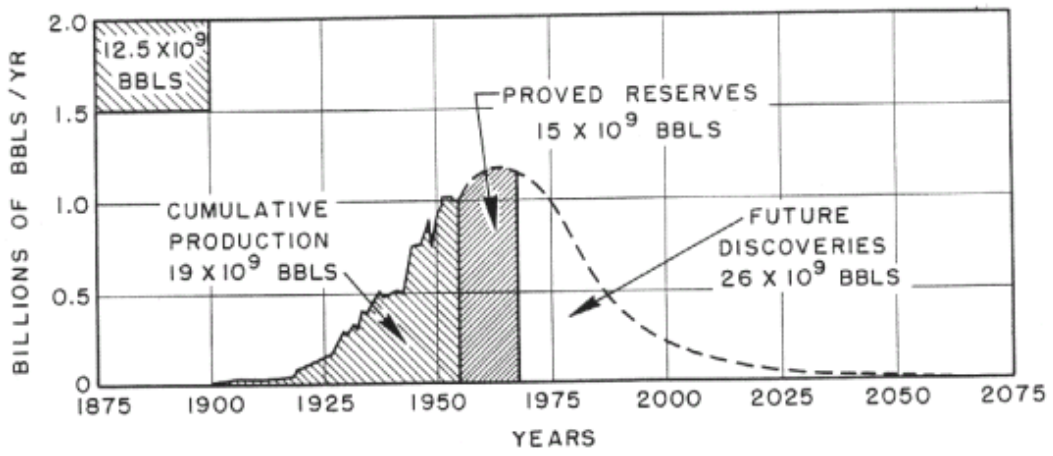
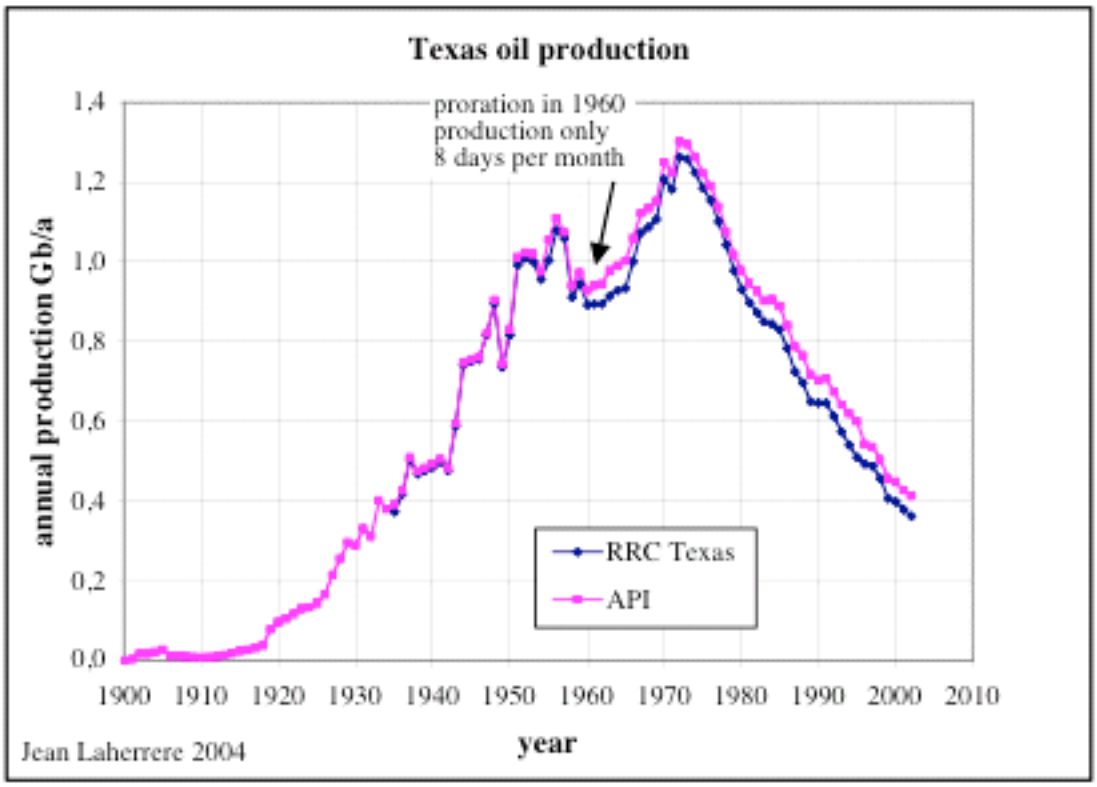
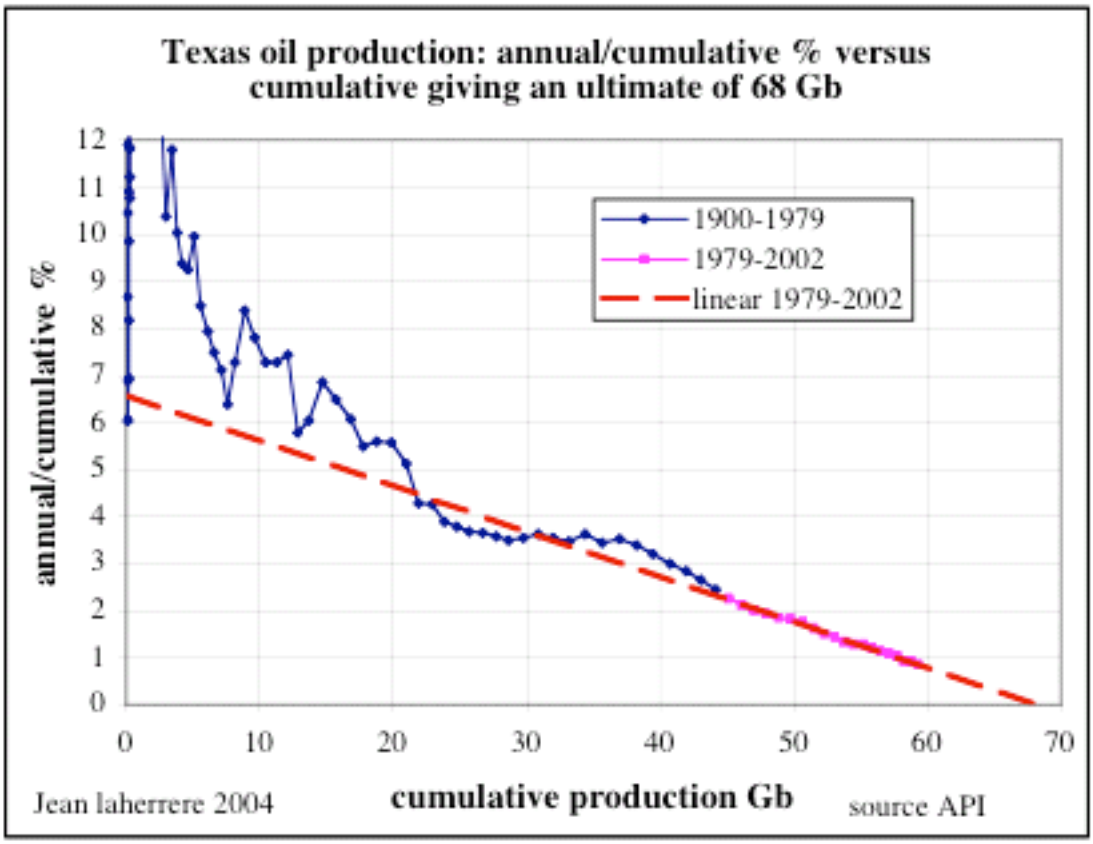


Figure 23 - Ultimate Texas crude-oil production.

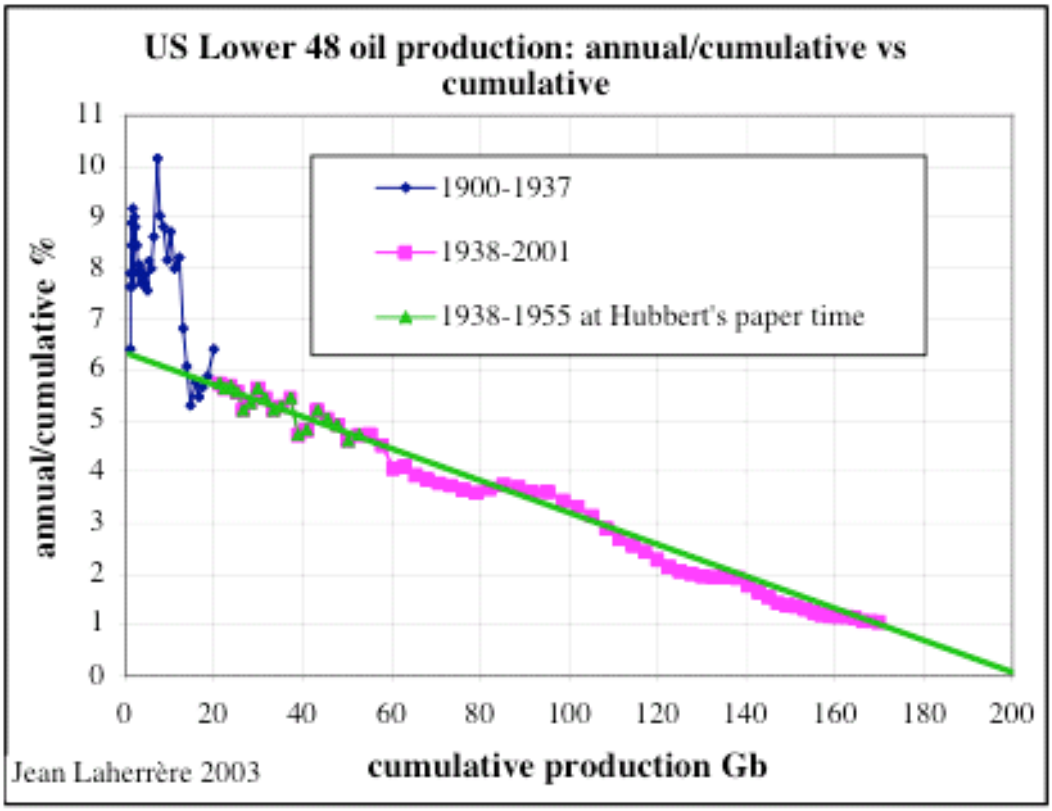
In fact Texas oil production displays two peaks and Hubbert missed the first one in 1956 (decrease due to proration in front of increasing imports in 1960 production was allowed only 8 days per month), the year of his writing and the main one was in 1972 at 1.3 Gb/a and the production was at 0.4 Gb/a in 2000.



The Texas ultimate is about 68 Gb from the extrapolation of the past production (annual/cumulative versus cumulative). Hubbert was wrong by 10%, which is fair.

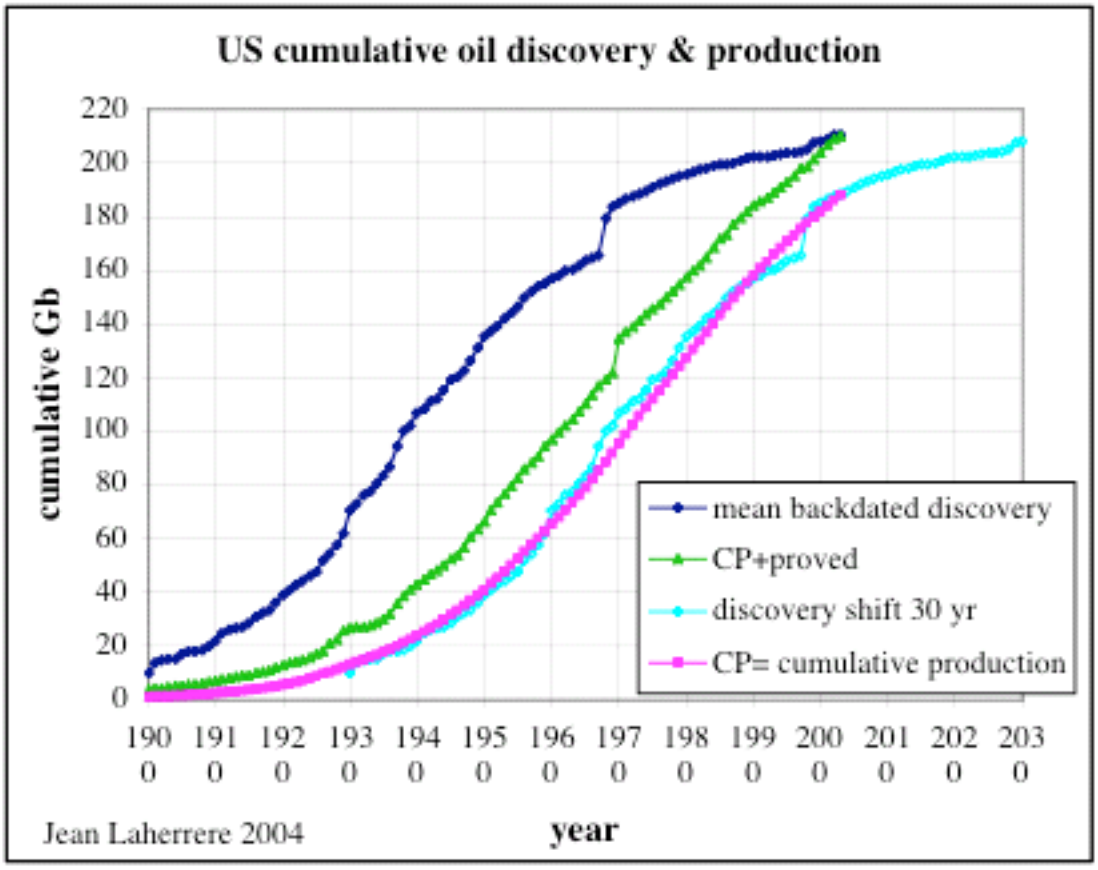


-2: OGJ Sept.2, 1963: « US reserves put at 600 billion bbl »
It is written:
<<Hubbert estimated ultimate potential reserves, including past production to be 175 Gb (OGJ Jan.21 p48). Said the USGS paper: « Hubbert's estimates are based upon analysis of the rate of discovery, which he believes reached its peak in 1956 »<<
In 1956 plotting the past production as annual/cumulative versus cumulative could allow him to estimate the US Lower 48 ultimate at 200 Gb



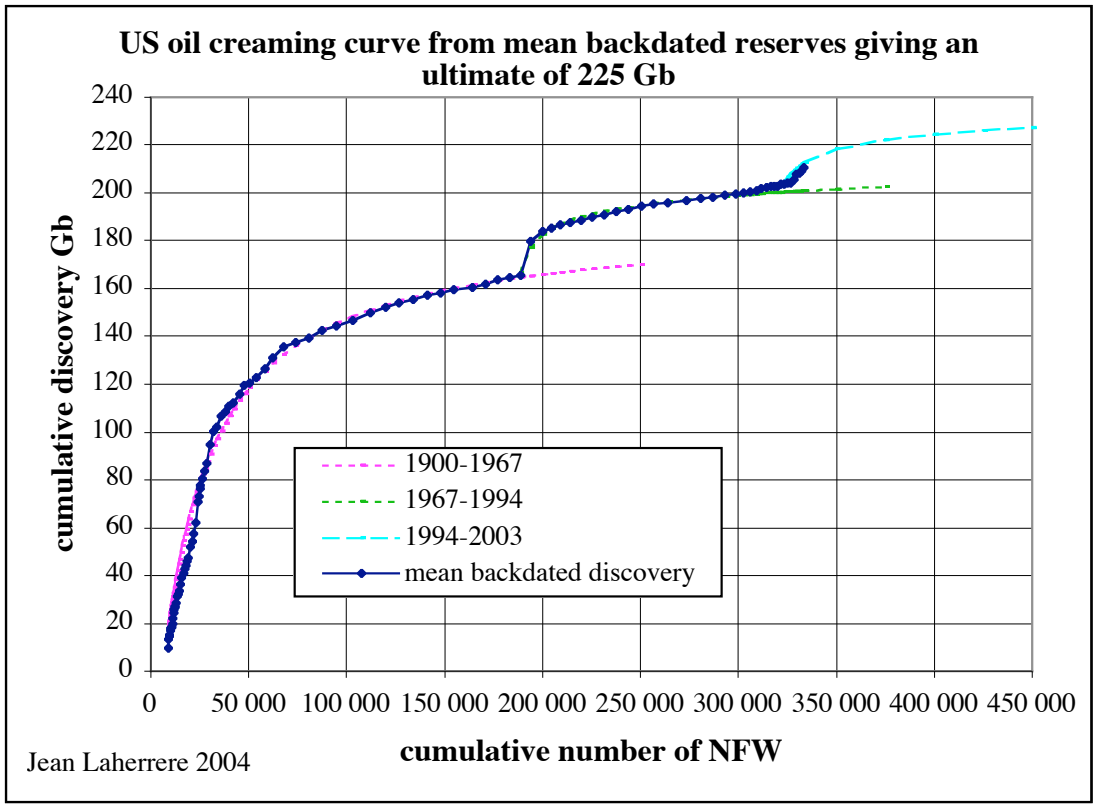
The weakest point of Hubbert argument is that he used proved current reserves and he did not mention the problem of using mean values and backdated value.
The plot of mean backdated (from USDOE/EIA report 0534 august 1990 « US oil and gas reserves by year of field discovery » and annual reports from 1990 to 2002 grown with MMS growth function) and current proved reserves as cumulative discovery shows a large difference despite the same value for 2002 (as now proved reserves represents a probability of about 50% closer to the mean value than to the SPE/WPC

proven value of P90 as shown by the graph on US probability of estimate).

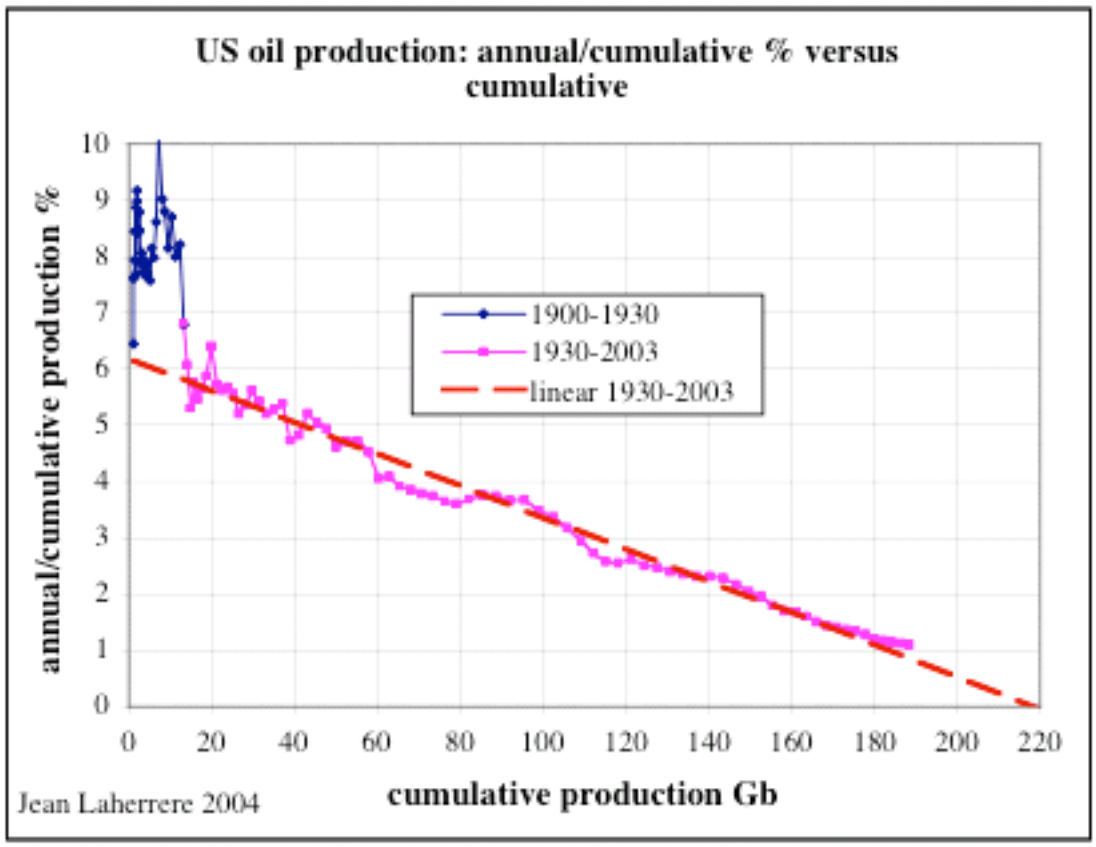


The mean backdated cumulative discovery trends towards 220 Gb when fitted with a logistic curve, but it is obvious to any eye, and it is also the ultimate given by the further graph displaying annual/cumulative% versus cumulative production. It is also close to the asymptote of the creaming curve which is 225 Gb for an additional 70 000 new field wildcats representing over 40 years of drilling as for the 90s (1500 NFW/a)
The cumulative production fits very well with the mean backdated discovery shifted by 30 years.
The cumulative discovery represented by the cumulative production plus the current proved reserves is trending towards a much higher value and cannot fit when shifted as well the mean backdated curve.

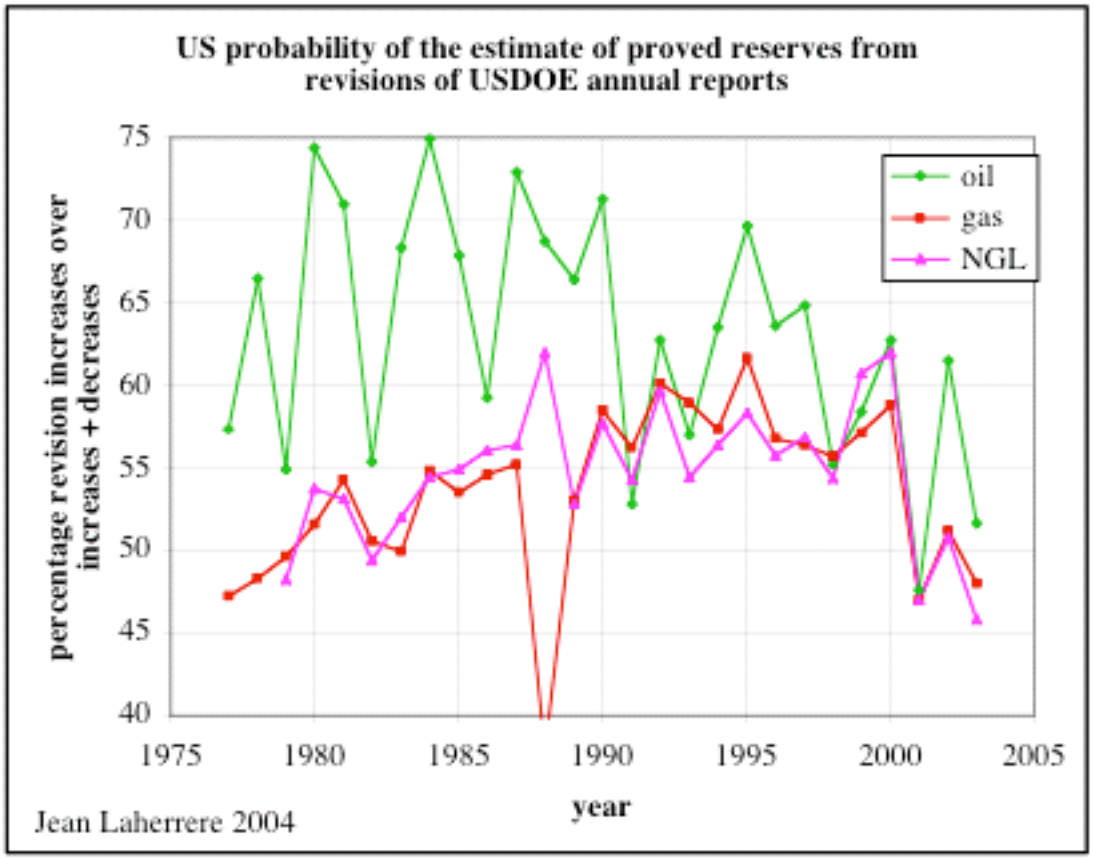
Graph showing the US creaming curve



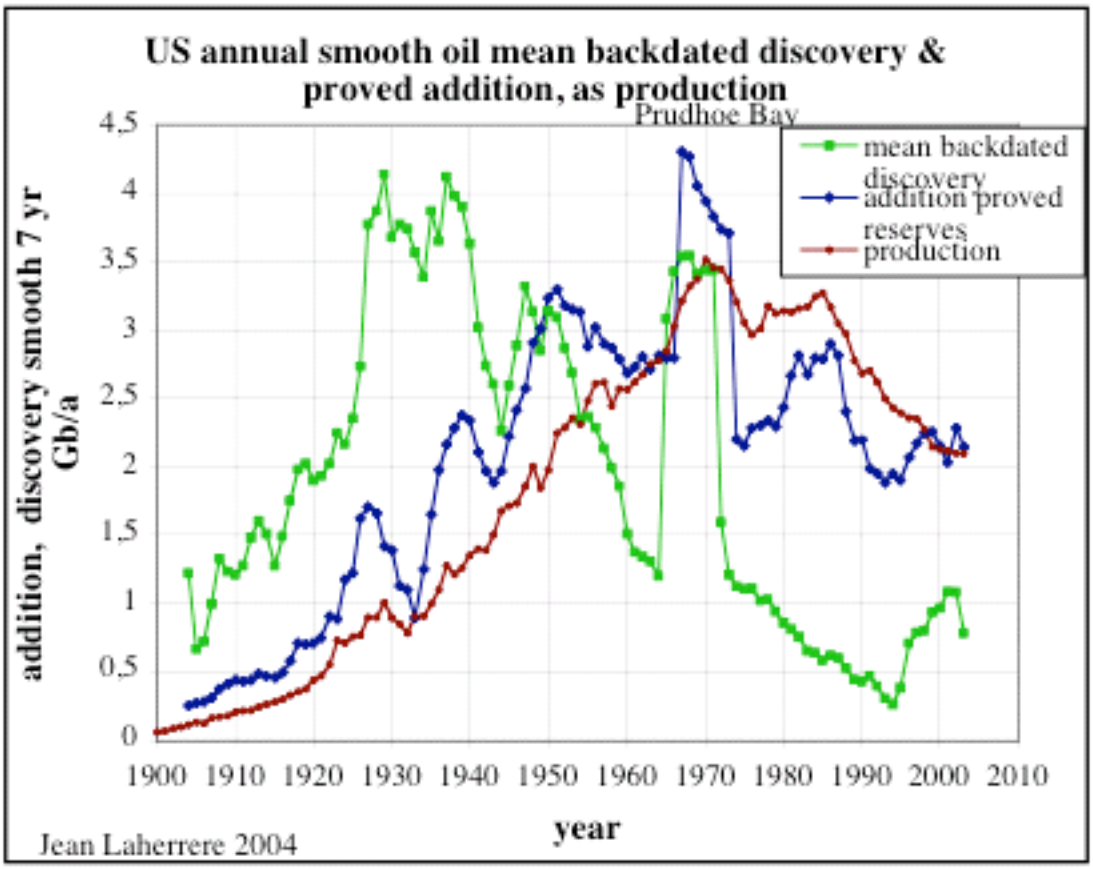
Graph showing that the extrapolation of the percentage of annual production over cumulative production versus cumulative production trends to an ultimate of 220 Gb for a zero annual production



Graph giving the probability of the estimate of the proved reserves, being the ratio of the positive revisions versus the sum of positive and negative revisions. The value for oil, natural gas and NGL trend towards 50% and even below, as the probability of a mean value is about 40 %. I have already displayed a similar graph starting in 1970 for oil but I found that it is better to start in 1977 to keep homogenous value (from the USDOE/EIA as before it was API and AGA values. When EIA took over reporting the values in 1977, there were significant discrepancies with the previous system, showing the poor accuracy of these values.

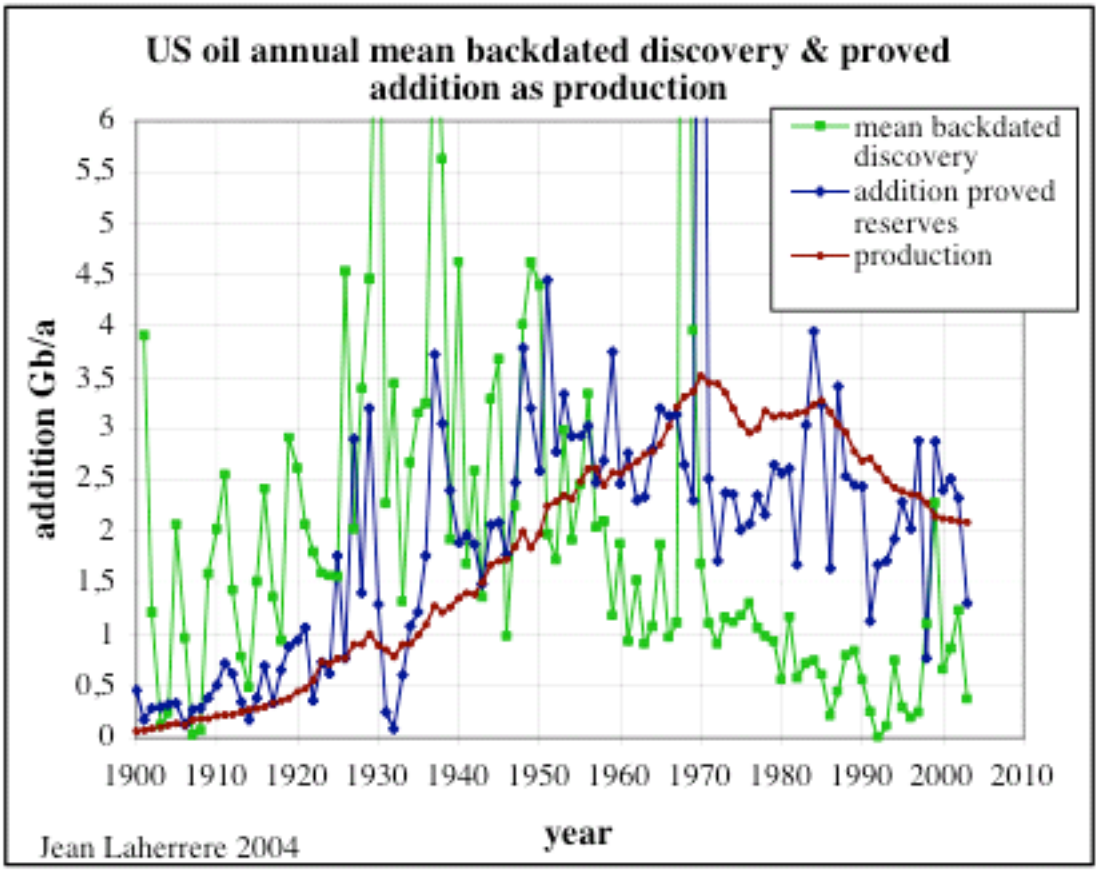


The annual discovery represented by the mean backdated estimate or by the addition of current proved reserves displays when smooth on a 7-year period a large difference. Excluding the Prudhoe Bay discovery around 1970, the current proved peaks in the 50s as indicated by Hubbert in this OGJ article when the mean backdated value peaks around 1930 as known by all geologists as the Lower 48 largest field: East Texas was found in 1930.



On this graph annual production is not far from addition of current proved reserves, meaning no worry when the backdated discovery is quite smaller than discovery, meaning that the depletion of oil is very important.

Same graph with no smoothing



-3- Hubbert 1959 « Presentation of prediction with application to the petroleum industry « 44th AAPG Dallas March 1959
Hubbert displays a rate of crude oil discovery 1900-1957 in figure 12 from the proved values peaking around 1950 and in figure 13 another rate reported by API giving a different trend, almost flat.

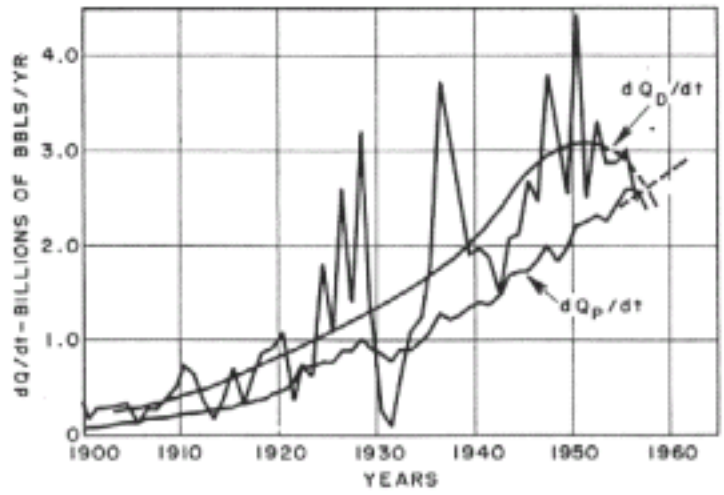


Fig. 12.-Rates of crude-oil discovery and production in the United States.

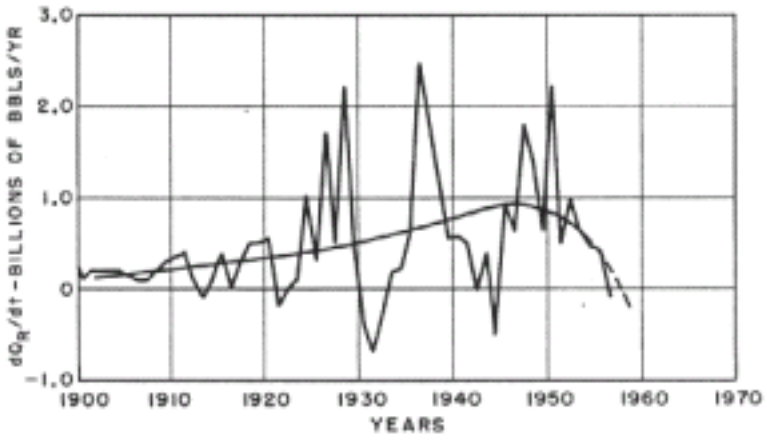


Fig. 13.-Rate of increase of API estimates of crude-oil proved reserves in the United States.

He should have tried to find which rate was right. On figure 14 he presents a state of evolution with discovery peaking at 1952 and production forecasted peaking 10.5 (what accuracy!) years later. However his figure 20 shows the rate of discovery of fields greater than 100 Mb peaking around 1930 (with a trough in the middle due to the depression) peaking around 1930 and production peaking 24 years later (as figure 19 on cumulative discovery and production fitting parallel logistic curves).

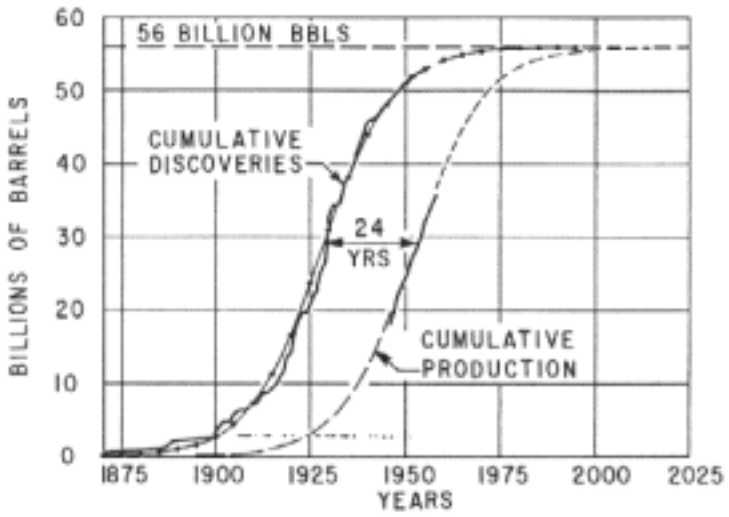
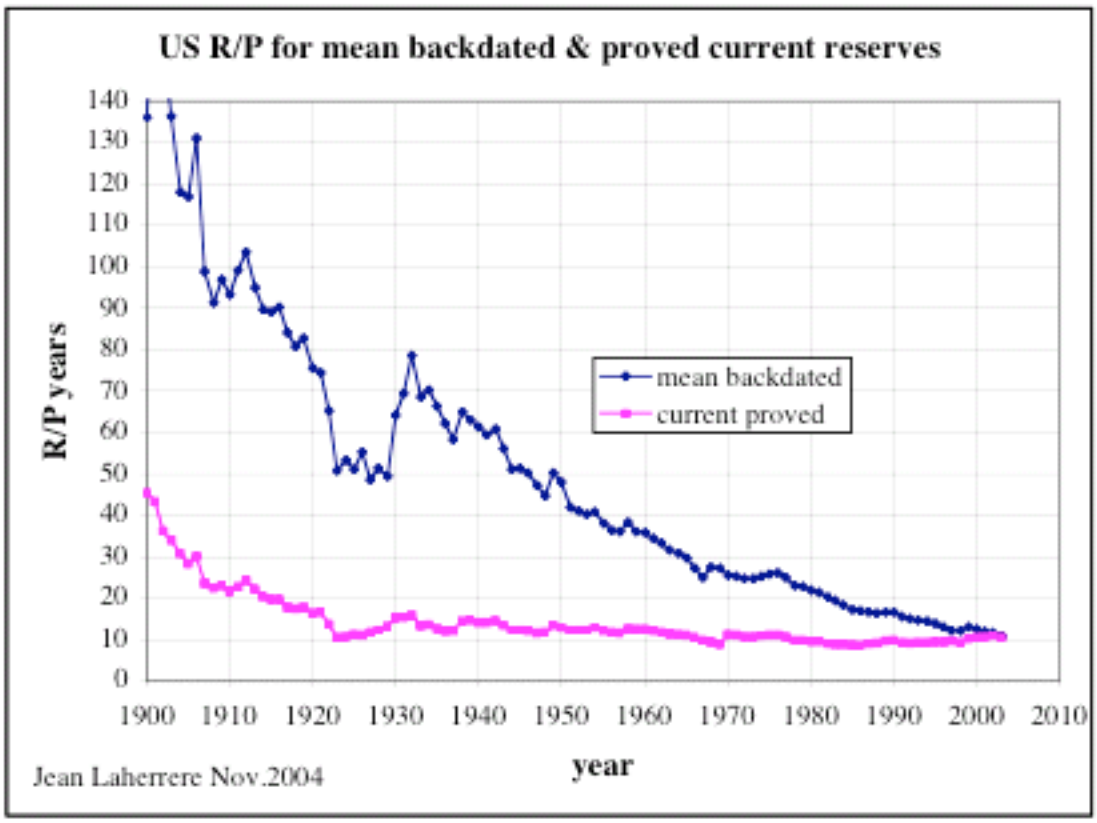
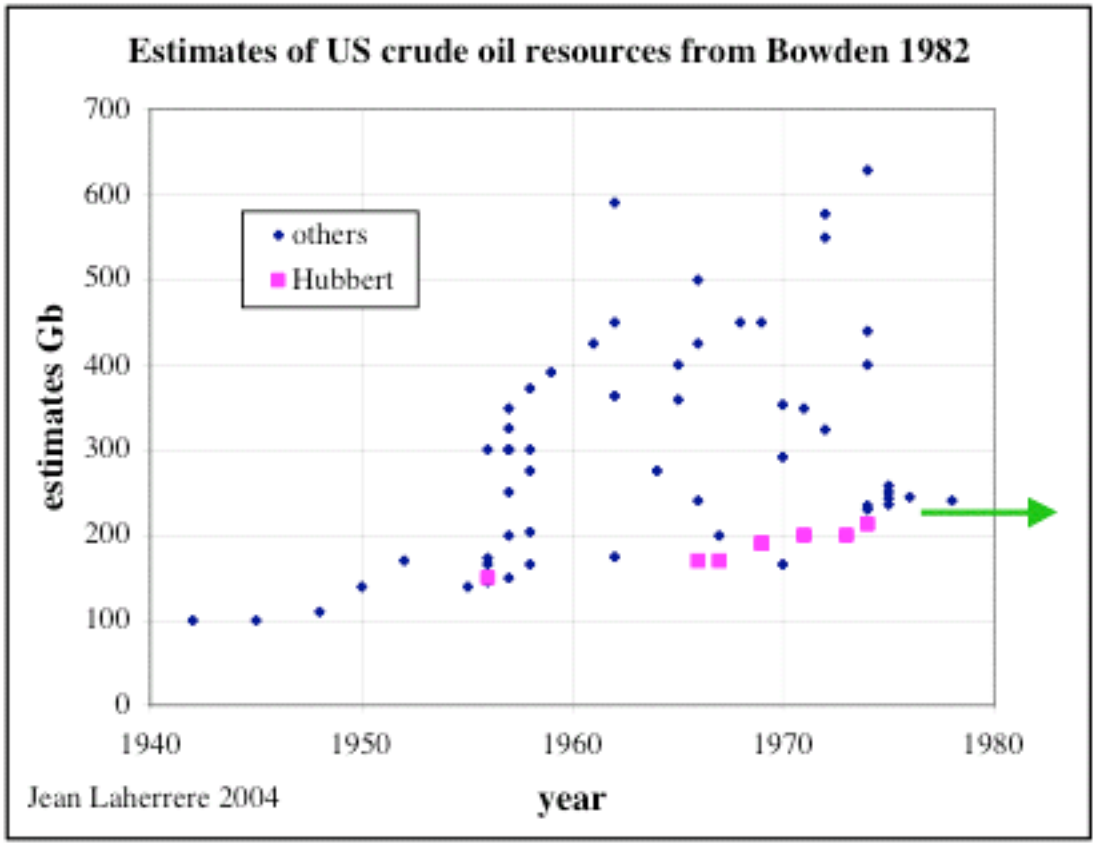


Fig. 19.-Cumulative discoveries and cumulative production of ultimate reserves of liquid hydrocarbons of U. S. fields greater than 100-million barrels.
(Review-Forecast issues of Oil and Gas Journal)

So Hubbert has seen the problem of using current proved reserves reported mainly to please the bankers and shareholders (as SEC present rules), but he did not dare to move to mean backdated values, which provide much, better forecast as it represents better the reality.
The ratio R/P (reserves over production) in years is used by mainly economists to show that there are many years of production left, but for the US the past data for current reserves have stayed around 10 years since 1920 meaning that this ratio is useless when computed from mean backdated remaining reserves R/P has been decreasing from 80 years in 1920 down to 10 years now trending towards zero in few decades



-4: Bowden 1982 « Estimating US crude oil resources Pacific Sociological Review October p419-448
Bowden reports the US oil estimates from 1942 to 1978. He finds that after a slow start estimates were chaotic from 1957 to 1974, but after, when the US oil peak in 1970 was recognized, the estimates were about 240 Gb (Exxon and Nehring which know well the data). Hubbert started at 150 Gb in 1956 and slowly increased up to 213 Gb in 1973. These last estimates are close to my estimate of 225 Gb (210 Gb already discovered in 2003 and 190 Gb produced). In his 1956 paper Hubbert used 150 Gb as his estimate to forecast a peak in 1965 and 200 Gb as the highest estimate from an enquiry by Pratt to forecast a peak in 1970, which was right.



It should be interesting to update this graph with estimates from 1979 to 2004.

-5: Bowden 1985 («The social construction of validity in estimates of US crude oil reserves » Social studies of science 15, May, p207-240)
Bowden updated his 1982 graph to 1980 but without giving the details. He mentions that Martinez notes that many countries have experienced multiple peaks and that, if Hubbert has mentioned the possibility of multiple peaks, he does not address the issue in his empirical work. Bowden added that « *peaking of production does not necessarily entail the accurate calculation of ultimate production. Most astonishingly, Hubbert has abandoned the use of the technique as a means for estimating ultimately recoverable world crude oil sources because, by his own admission, it yields erroneous results.* »
In fact Hubbert did not know the technique of « creaming curve » introduced later by Shell, which is the best way to estimate ultimate.
Hubbert also did not mention the symmetry of the bell curve as the result of random when dealing with a large number of independent actors as in the US with over 20 000 producers. It is why many countries do not behave as the US, having few producing companies.

Hubbert was a real finder in oil exploration, not as an explorer, but more as a teacher. His best contribution in oil finding was on the hydrodynamics of water aquifer and oil-water contact tilting, giving a new approach on oil accumulation.
On the Hubbert curve, he was following Hewett's 1929 paper on ' Cycles in metal production » wherer geology is first, followed by technology, then economics and last politics. He was a brilliant thinker mainly applying simple ideas as production goes up and comes down. He was not afraid to go against the crowd.

He deserved all the honors that he received.
Many points of his works were not right, but in fact being “dry holes”. As any oil explorer, he drilled many “dry holes”, but found many “giants and supergiants fields”.