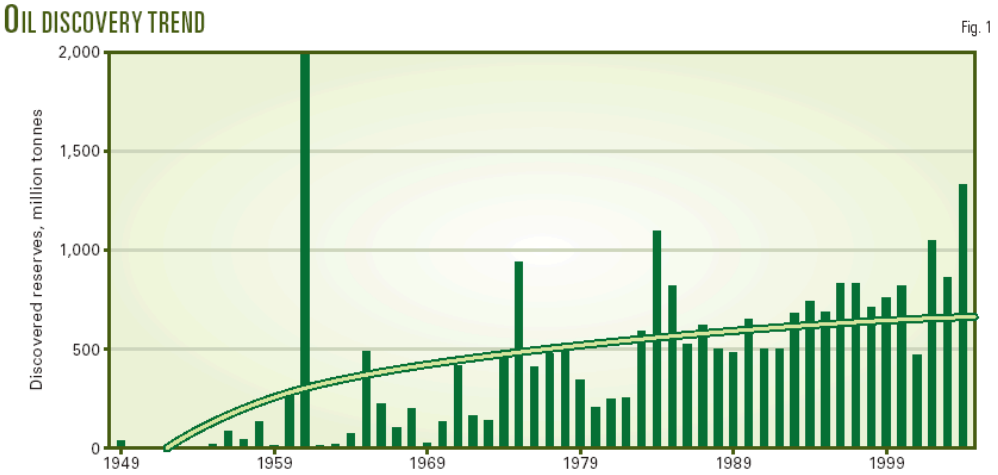
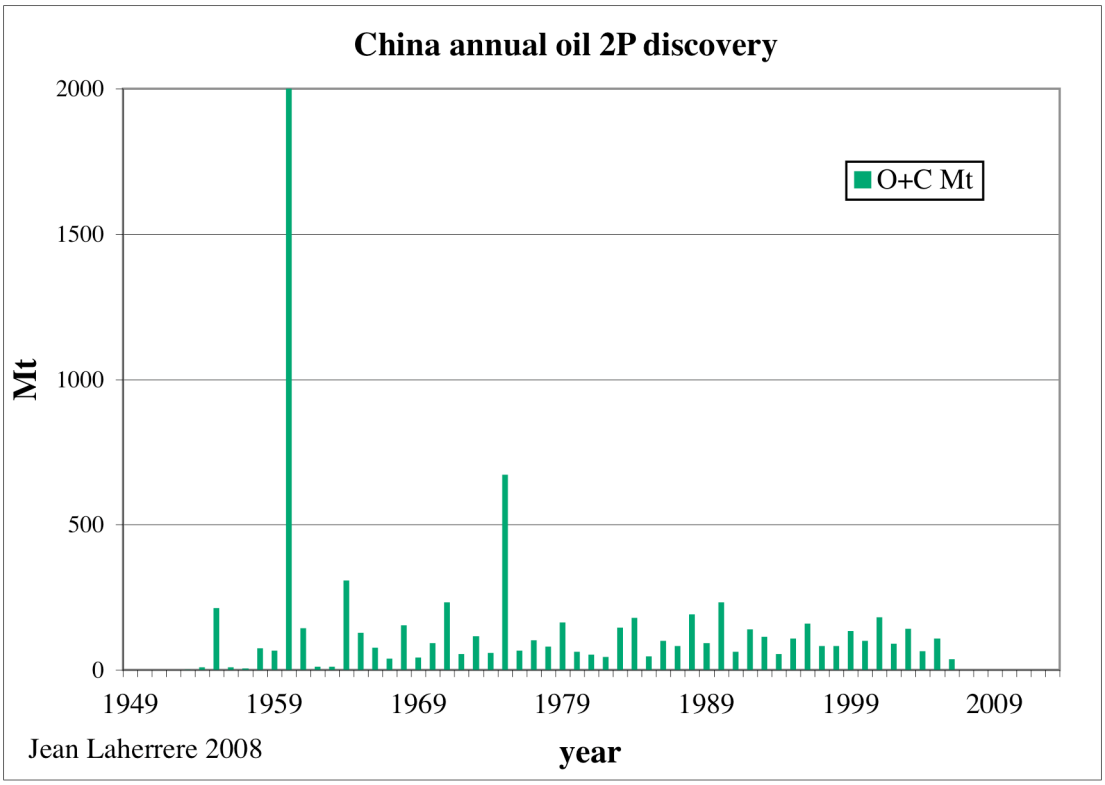
Jean Laherrere jean.laherrere@wanadoo.fr 22 January 2008

Questions to Feng Lianyong on the OGJ 14 Jan.2008 article :
"Peak oil models forecast China's oil supply, demand"

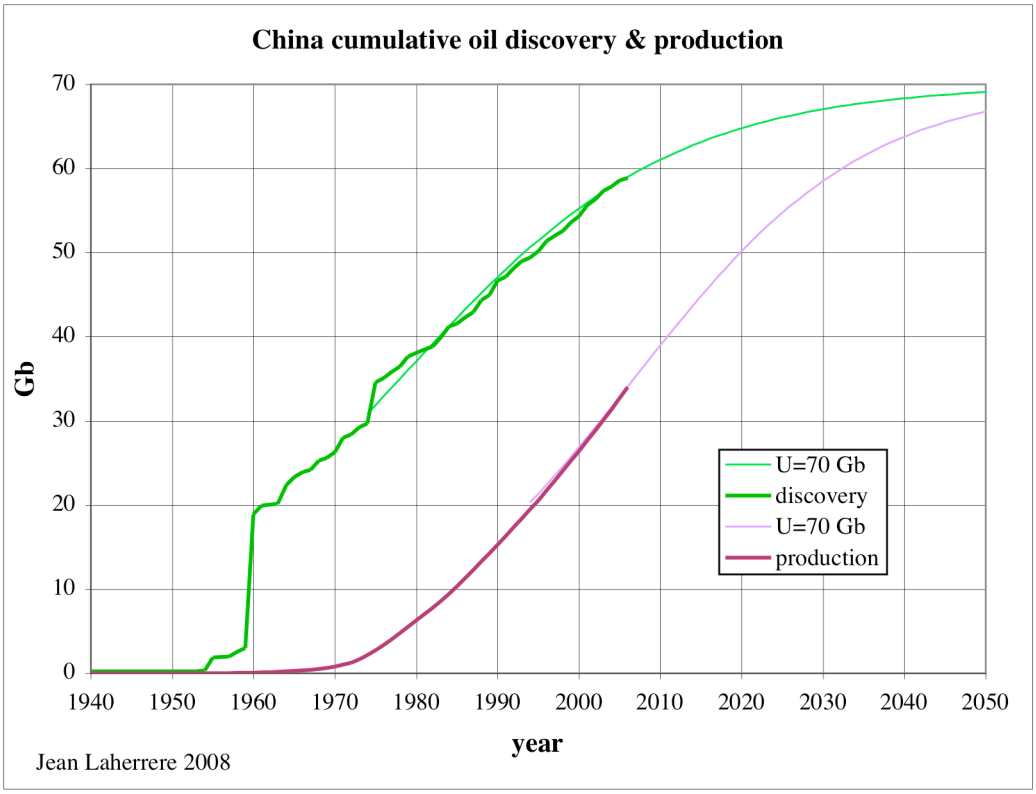
In his e-mail sending the article, Feng Lianyong asks for questions.
My first question is :
-1-**what is the discovery data shown in figure 1?**
Are they current proved discovery as usually reported by medias following SEC rules or backdated proven+probable discovery ?



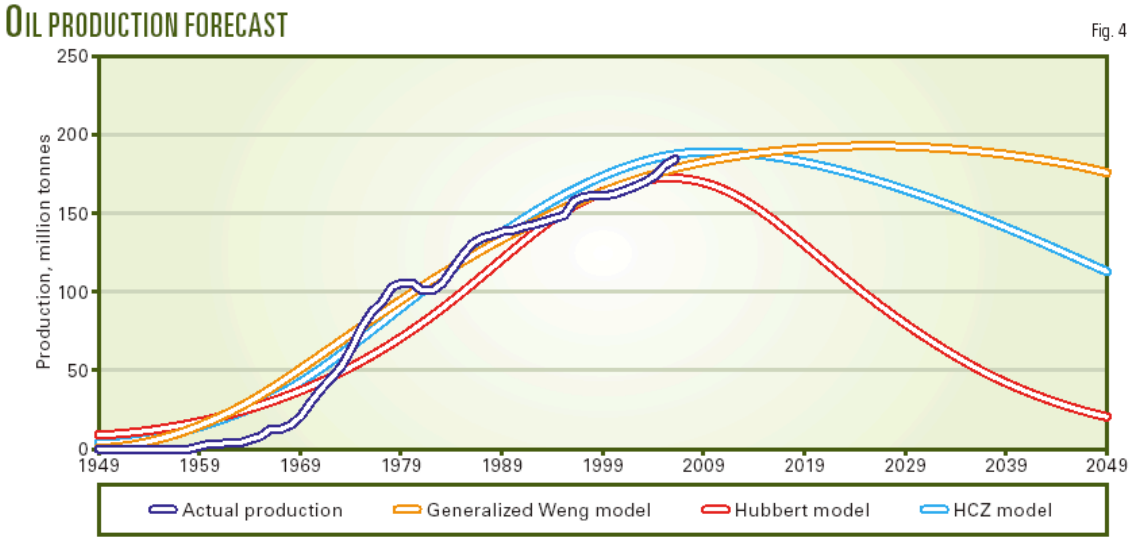
IHS 2P backdated data shows different value except for the Daqing complex discovery (1960)



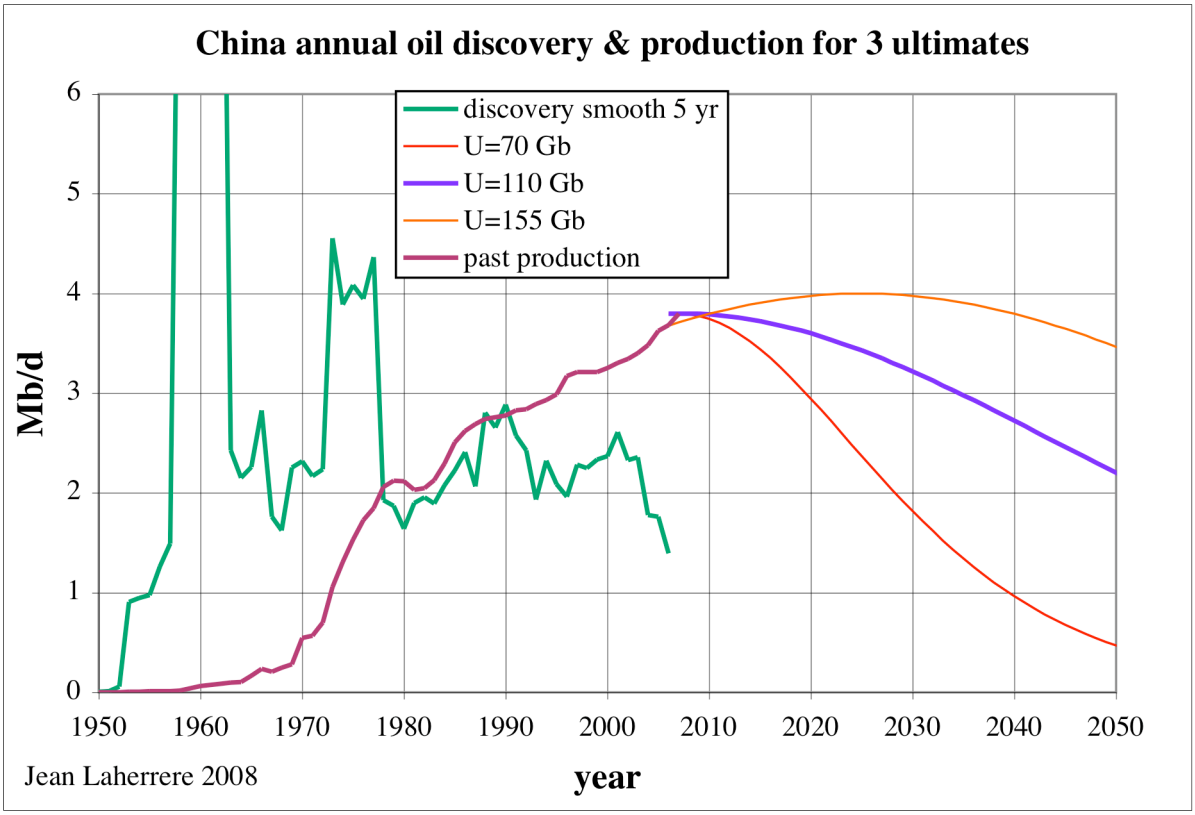
The cumulative 2P discovery can be modeled in time with a logistic curve for an ultimate of 70 Gb which agrees with the modeling of the cumulative production for the same ultimate



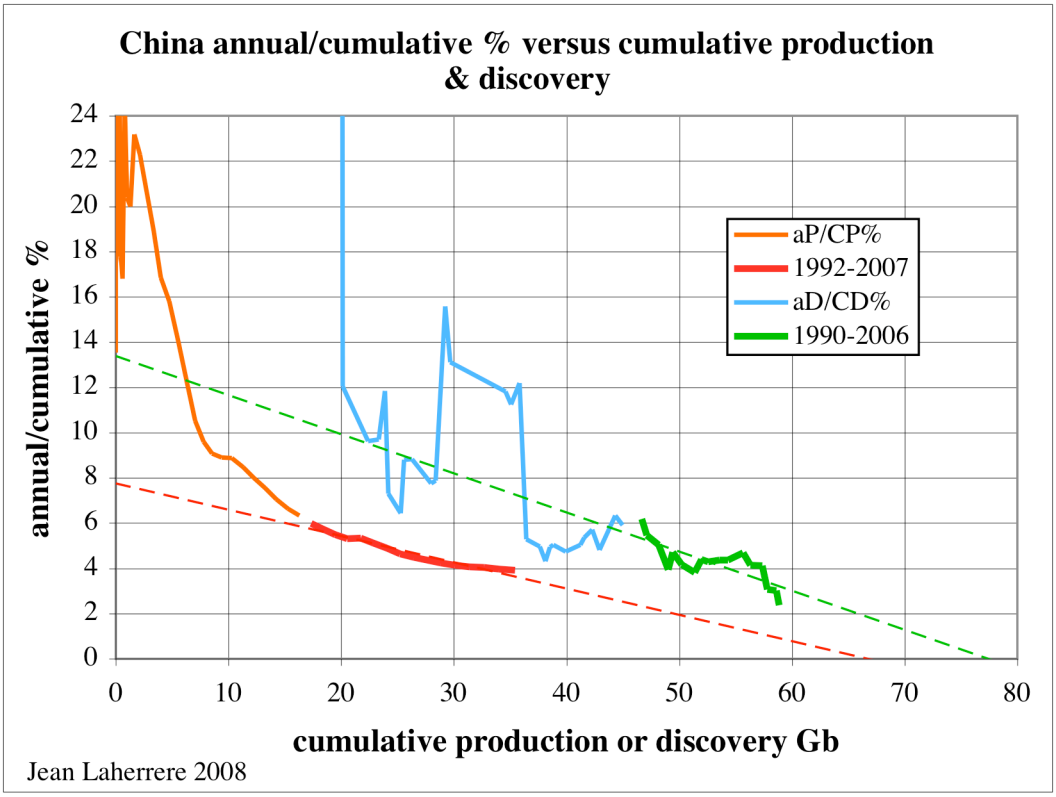
-2- Table 1 gives 3 models with 3 equations but does not reveal the ultimates of the 3 models shown in figure 4. What are the ultimates for Weng model, Hubbert model and HCZ model ?
Hubbert'approach in his 1956 paper was mainly :
-a- production pattern mimics discovery pattern with a certain lag
-b- production starts from zero, increases, peaks and declines back to zero. Hubbert was drawing the forecast **by hand** counting the square below to fit to the assumed ultimate.
-c- the curve was a bell-shape curve but not necessary symmetrical (see for world production)
-d- the shape of the curve is not very important, but the area below the curve being the ultimate
-e- for the famous US (Lower 48 because Alaska joined only in 1959) the curve was almost symmetrical modeled not on the proved reserves but with geological ultimates from the Delphi enquiry carried out by Wallace Pratt : 150 Gb was Hubbert's guess and 200 Gb was the highest value from Pratt's survey, which was proved to be close to present estimated USL48 ultimate.
Your Figure 4 can be modeled by a logistic derivative (usually called Hubbert) model for 3 different ultimates fitting the plotted models called Hubbert, Weng and HCZ, which present a similar shape despite different equations..



The 70 Gb ultimate (shown in the above cumulative extrapolation) gives a model (past production = 35 Gb plus future peaking in 2007) close to the Hubbert model of figure 4. A 110 Gb model (35 Gb past plus future peaking also in 2007) is close to the HCZ model. A 155 Gb model (past 35 Gb, 25 Gb to peak in 2025 and 95 Gb decline) is close to the Generalized Weng model.

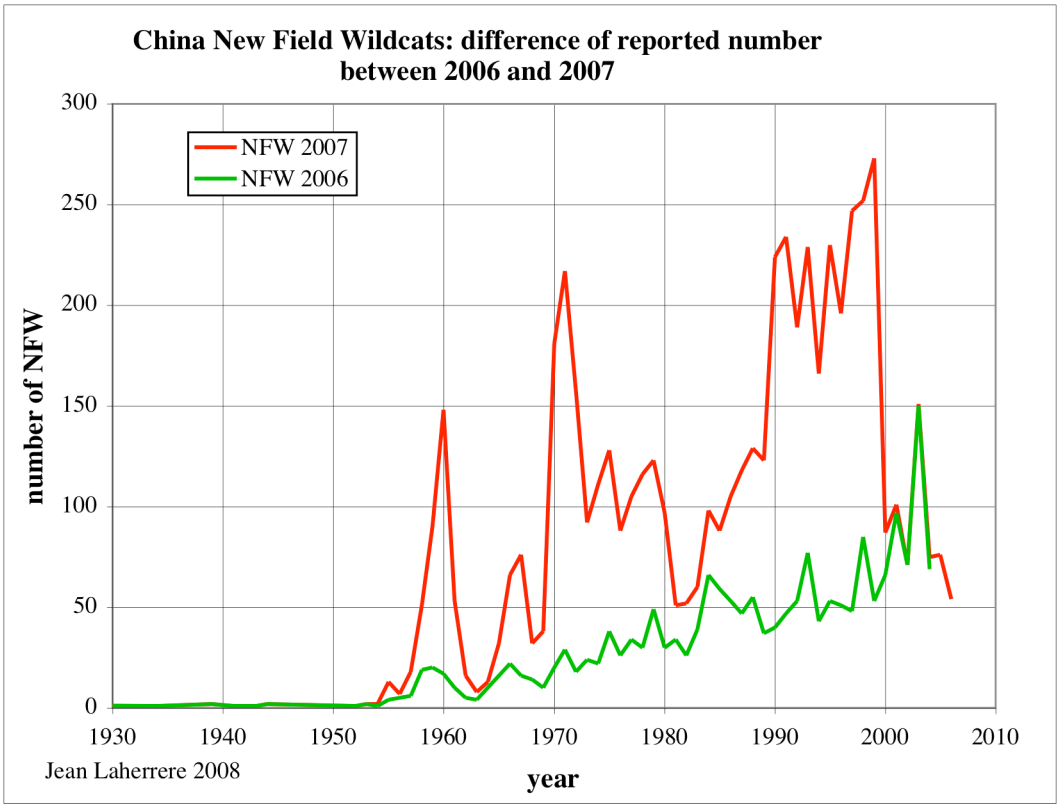


How do you justify such ultimates for your 3 models?
Ultimate can be estimated using the so-called Hubbert linearization = % annual/cumulative versus cumulative past production. If the pattern is logistic the plot should be linear. But in China linearization plot, it is obviously not linear, but the linear extrapolation of the past 10 years is not far from 70 Gb both for discovery and for production.

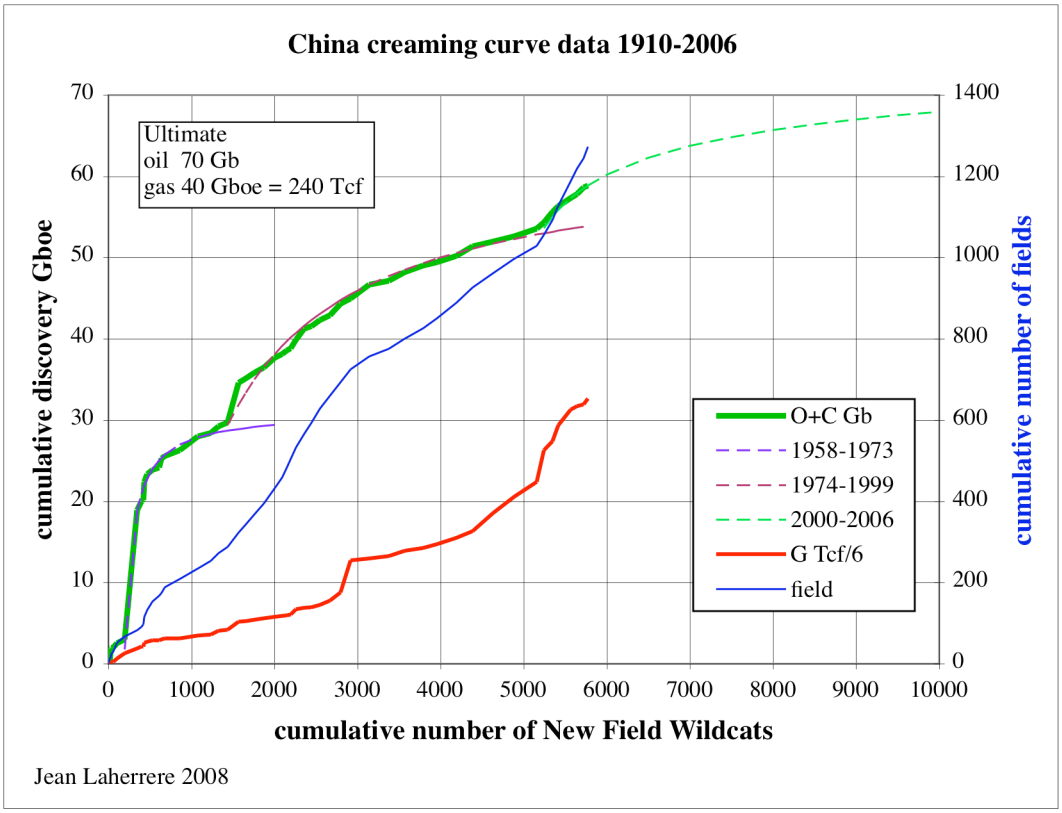


But the 1956 paper shows clearly that it was not Hubbert's approach to deal from mathematic of past production but from the geological knowledge (Pratt was the best oil explorer of his time) of the discovery potential.
The area below the production curve up to its end should be the same as the area below the discovery curve up to its end.

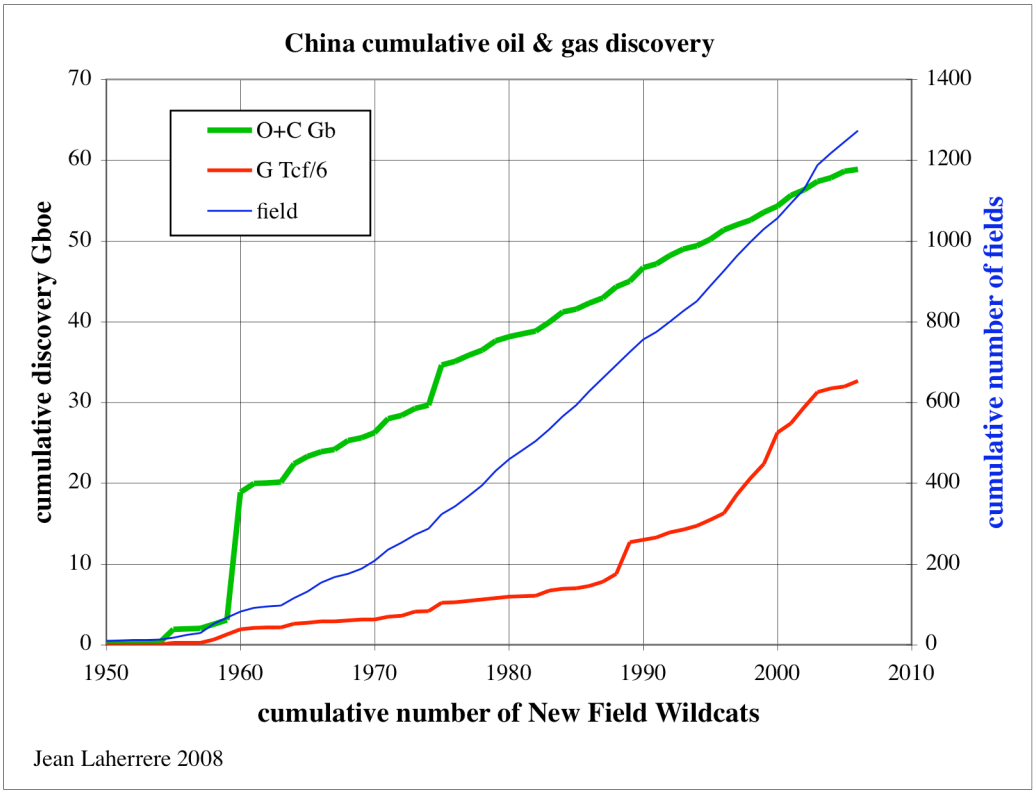
-3- what is the way that you estimate ultimate?
The best approach is to plot the creaming curve, which is the cumulative 2P (assumed to be the mean backdated value) versus the cumulative b number of NFW = new field wildcats (exploratory wells are often appraisal wells for tax reasons). This plot is rarely done because the database of the NFW are not available to most evaluators.
In my January 2007 paper at GPPI Potsdam I displayed a creaming curve for China but the data was incomplete with a cumulative number up to 2004 being less than 2000 NFW, when the new 2007 data is over 5600
The difference is huge, showing that database are often incomplete because the confidentiality of exploration



It means that(China data is hard to get and China should, as UK and Norway, publish more data and in particular creaming curve with backdated mean values.
Of course with this new data my estimate of ultimate has changed from 60 Gb last year to 70 Gb now The oil ultimate is the extrapolation of the third cycle. The first cycle was from 1897 (first reported discovery, despite that it is known that gas was produced a long time ago drilling with bamboos) to 1973 ; the second cycle is from 1974 to 1999, and the third cycle from 2000 to now. Geological knowledge is needed (mainly evaluation of the Petroleum Systems = generation from source-rocks) to guess if a fourth cycle is possible, mainly in deepwater. Unfortunately my geological knowledge on China is to old. However I assume that it will be less than the accuracy of the present discoveries.
It is interesting to notice that the exploration success ratio (number of fields discovered in blue) is changing, increasing sharply for the last cycle.
My guess for the natural gas ultimate is 240 Tcf, the cycles are different from oil, except for the last one.

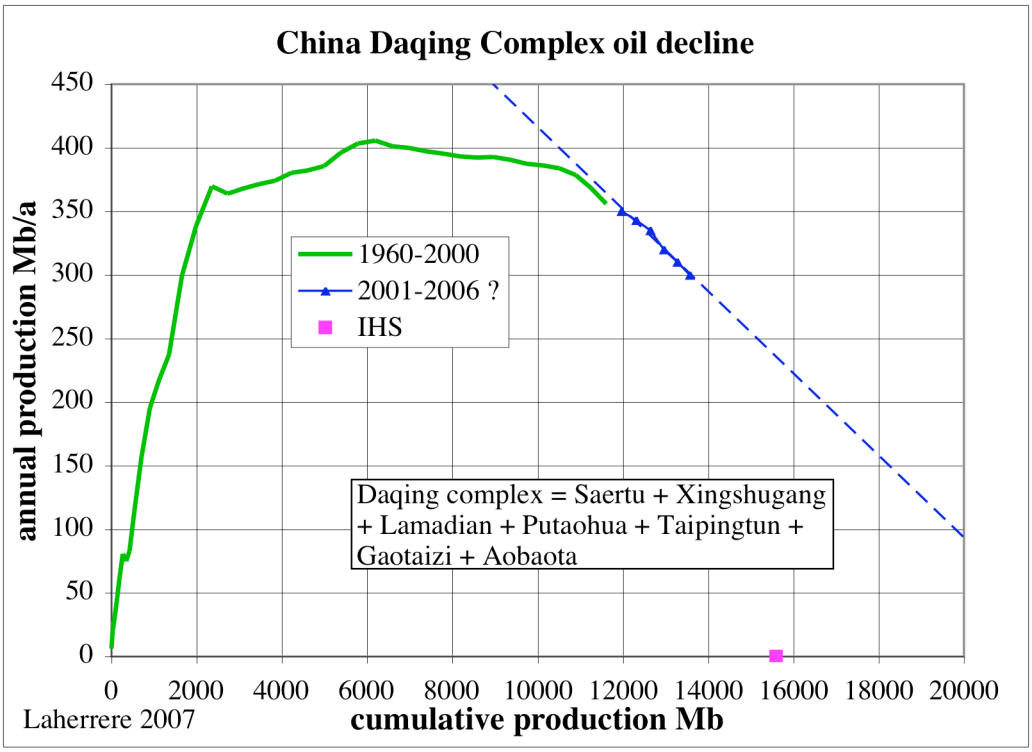


With she same data versus time, the trends are quite different, after Daqing it seems linear for oil, and also for the number of fields for the last 30 years.

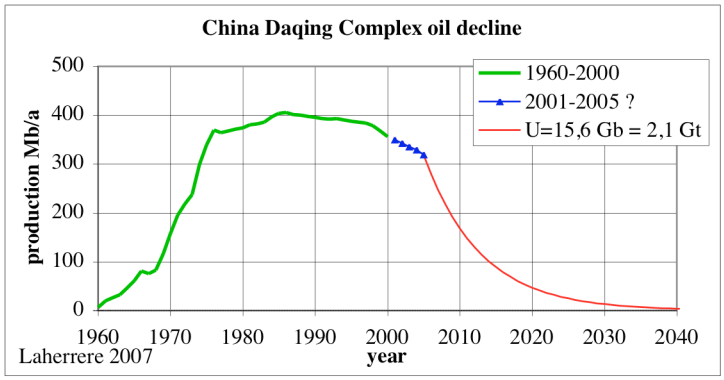


-4- do you check field reserves estimate with production decline?

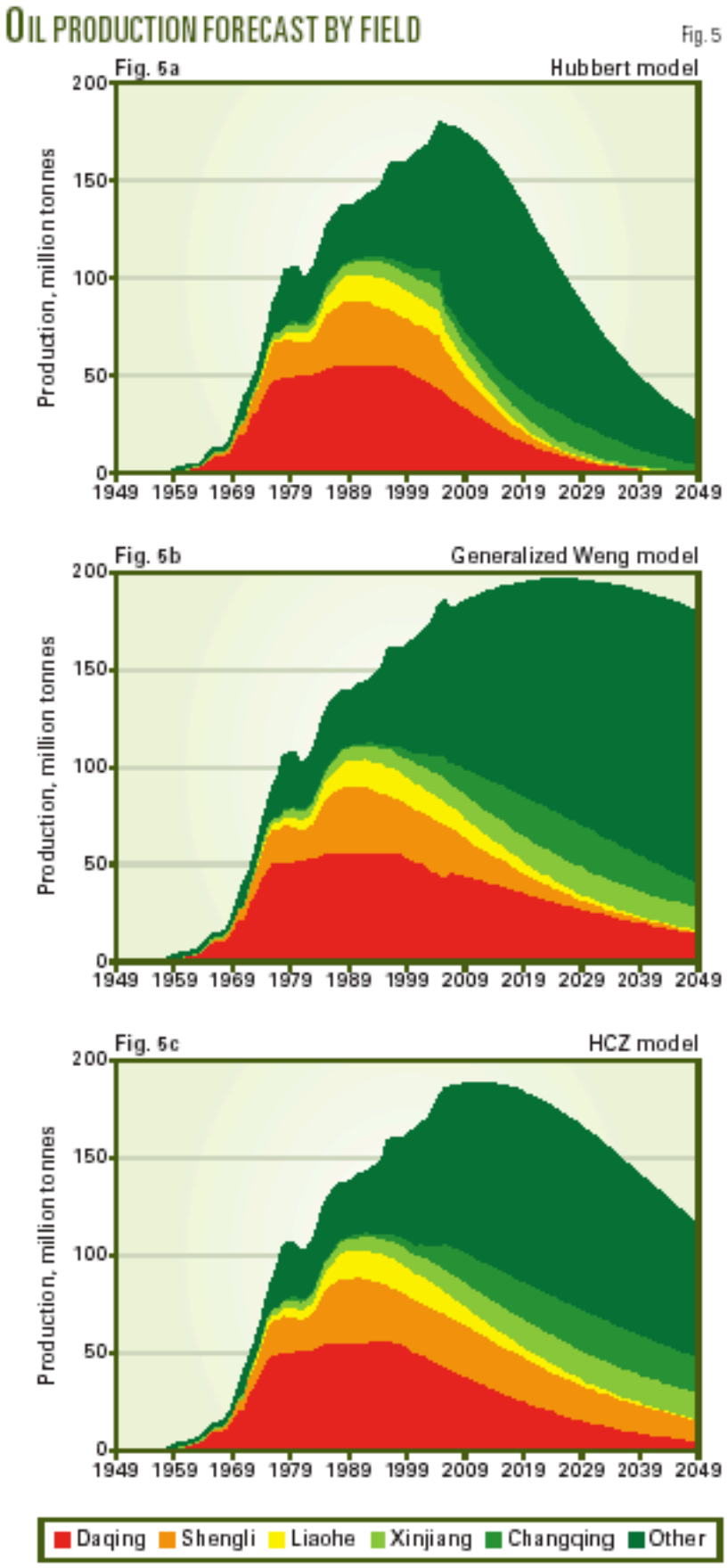
The reserve database has to be checked with individual estimate of the main field, because oil estimate vary with country. In particular the Russian classification (ABC1) is estimated (Khalimov 1979,1993) with the maximum theoretical recovery , making in fact a 3P estimate. There are little information on the method used to estimate Chinese oil and gas reserves
In my database, annual production by fields is incomplete. The Daqing complex is broken down in 7 fields with a total reserves at 15.6 Gb = 2.1 Gt (in line with the figure 1 data for 1960)
The extrapolation of past production in decline 2001-2006 is over 20 Gb when IHS reports quite lower with 15.6 Gb. But it is well known that Daqing complex being the main producer of China is produced at the maximum with many wells drilled and that the decline will be sharp.



The display of Daqing future production for a 15.6 Gb ultimate shows beyond 2006 a sharp decline (about 12 %),

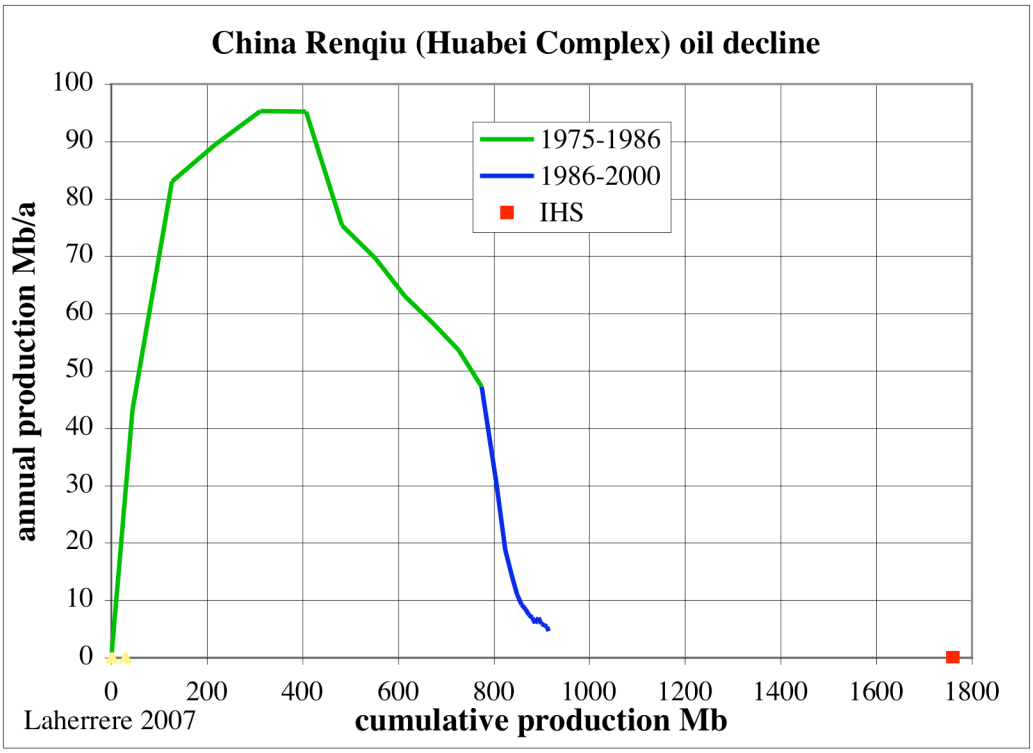


the field being exhausted around 2040 as shown in fig 5a
I am surprised to see in figure 5 that you show 3 different declines for Daqing complex (exhausted in 2040 for Hubbert, 2050 for HCZ and beyond 2060 for Weng), as if future production depends of the choice of the model. I guess that oil producers in Daqing do not bother with models !

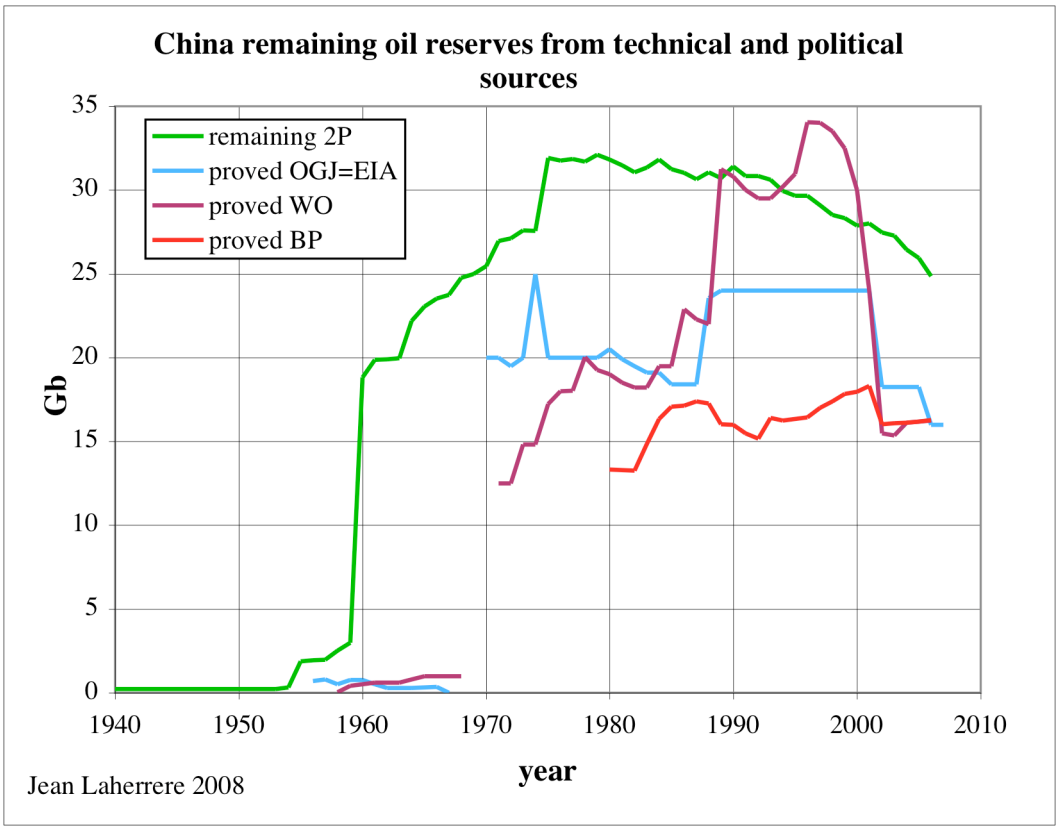


As Qaqing reserves estimate of my database seems maybe pessimistic I checked with Renqiu oilfield . Then the extrapolation of the sharp decline is quite lower (1 Gb) than the reported

reserves value (1.75 Gb). But Renqiu belongs to the Huabei complex which counts 27 fields which a total of 2,2 Gb.

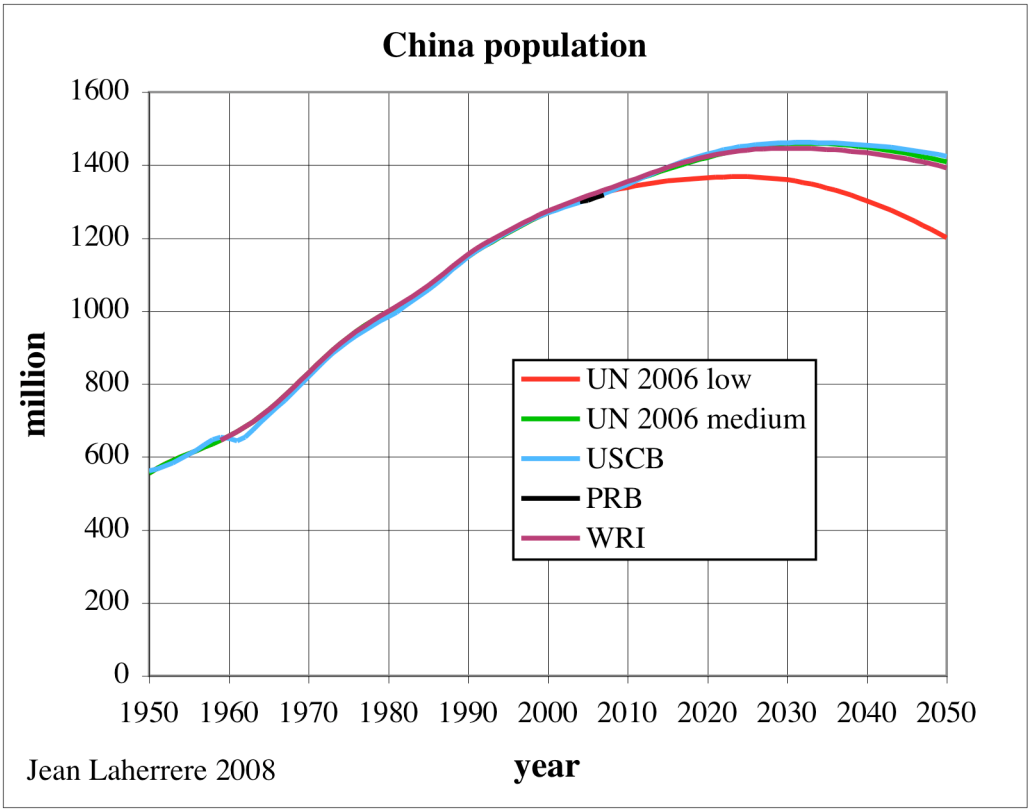


-5- **how do you compare China oil remaining reserves to the published data?**
It is interesting to compare the technical remaining reserves to the published data by USDOE/EIA, OGJ, WO, BP
My comparison is as follows :

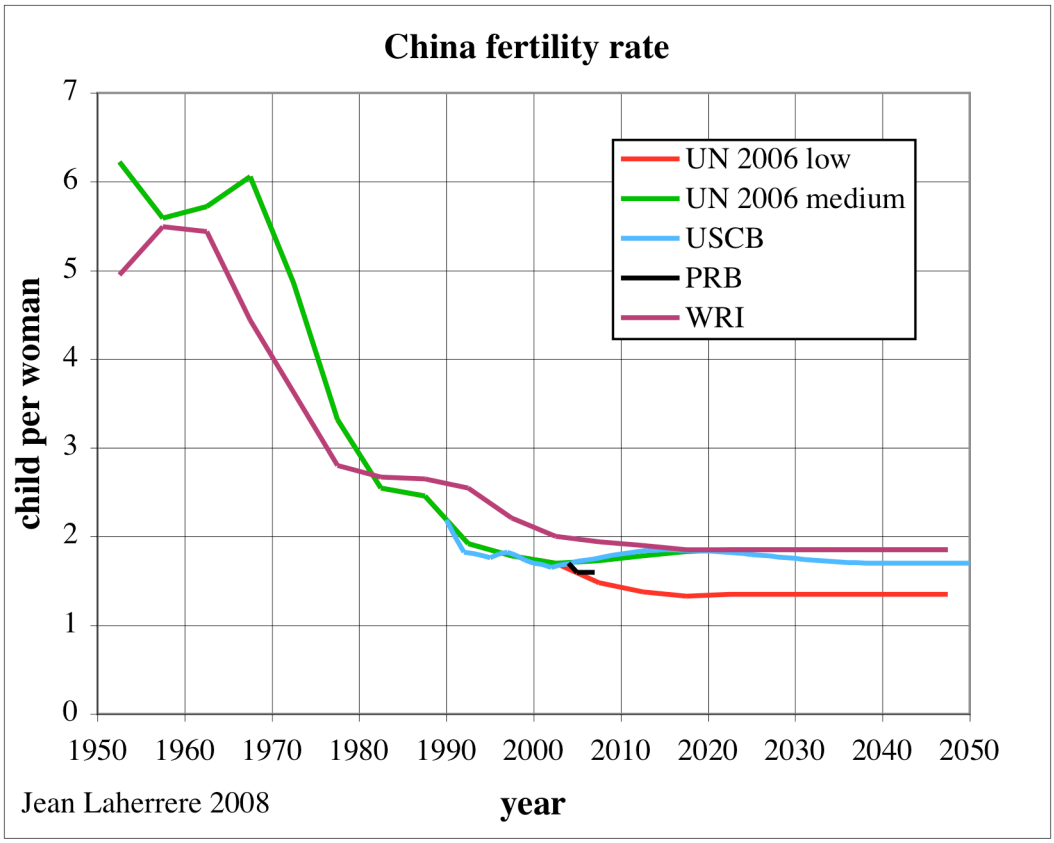


There are large discrepancies between the published data so China should report their own estimates regularly.

-6- oil demand : **what is the future oil consumption per capita?**
You compare oil demand with GPD but GPD is a bad indicator and quite manipulated everywhere (in the US with the hedonic factor) and represents expenditures and not wealth because more you borrow more you spend. It is better to analyze oil consumption per capita and to study the population forecast
UN 2006 forecasts are shown compared to USCB and World Bank WRI (earth trends)

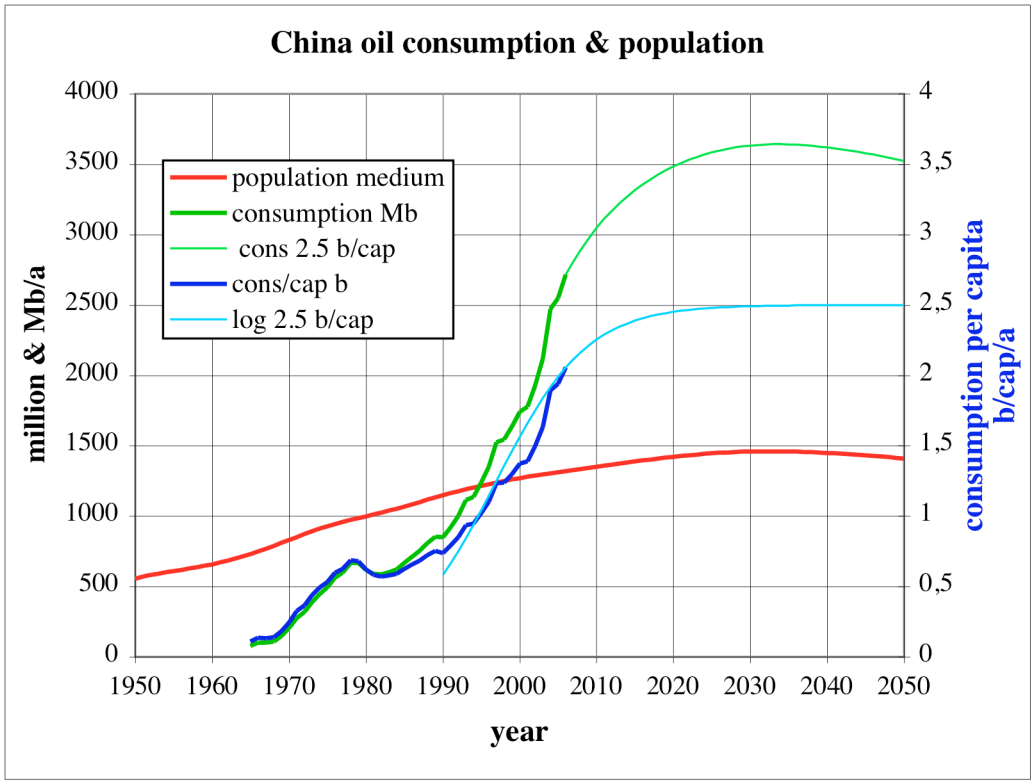


As population forecast depends upon fertility rate forecasts they are compared : WRI data differs largely with UN and USCB

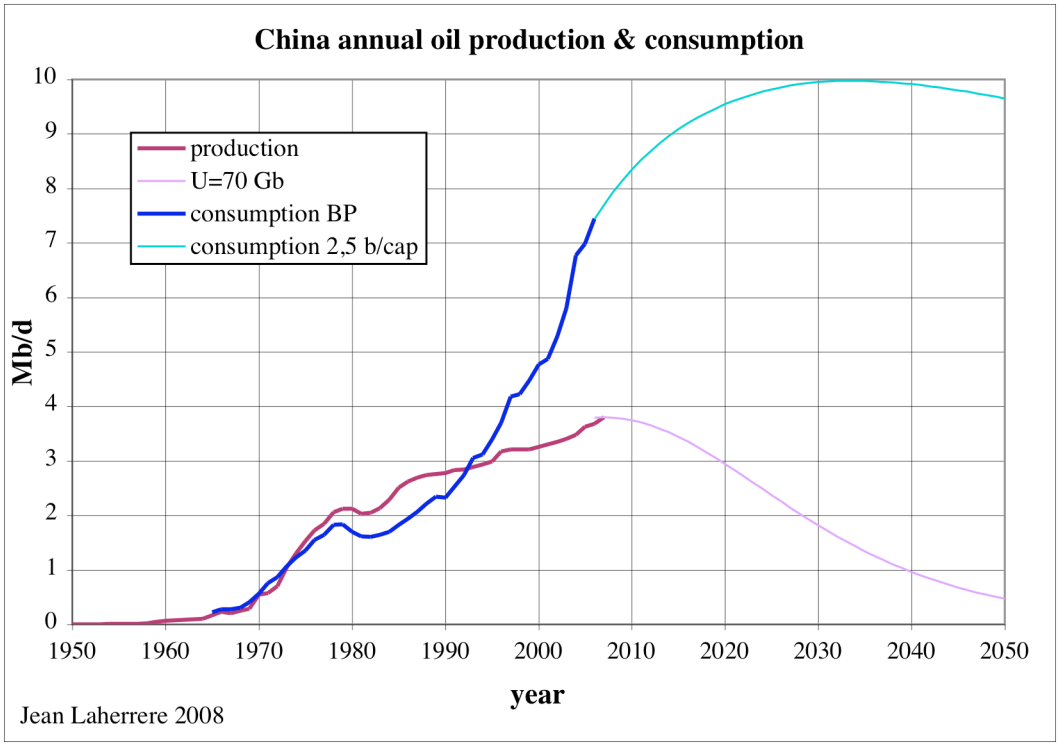


But the population forecasts up to 2050 are similar excluding the UN low fertility (theoretical to be the same for all)

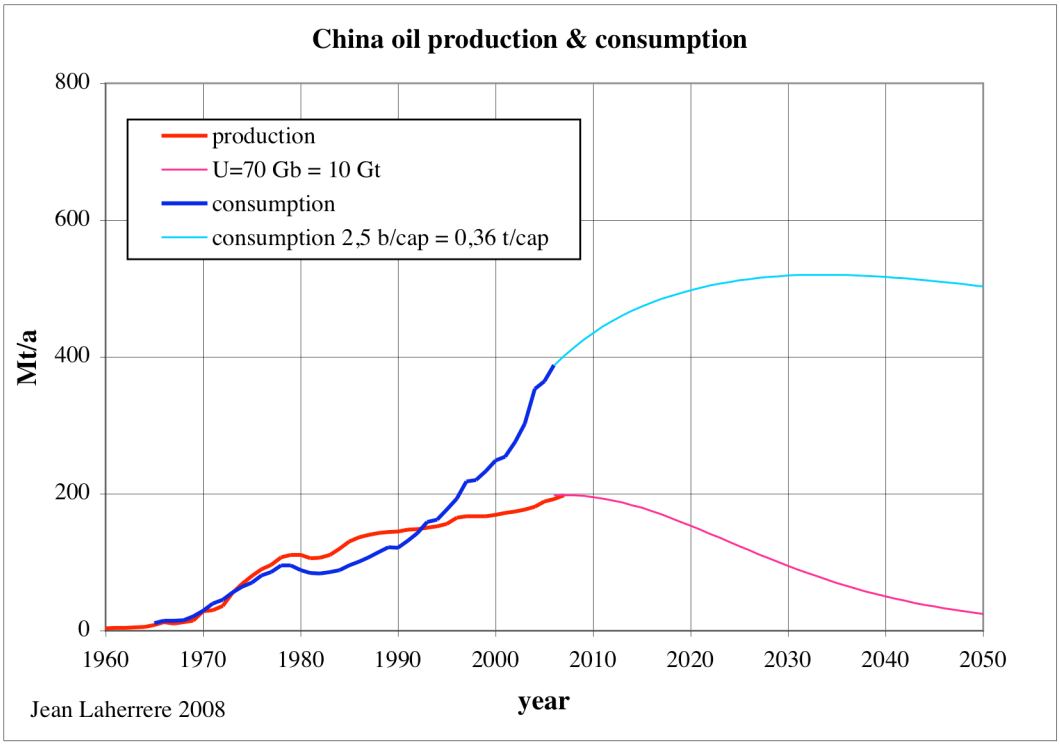
The oil consumption is compared to population. The consumption per capita has increased sharply from 1990 to now from 0,7 b to 2 b, but we assume that consumption will slow with high oil price and China oil peak. An asymptote of 2.5 b/cap is assumed ; giving a peak of consumption at 3,6 Gb/a or 10 Mb/d



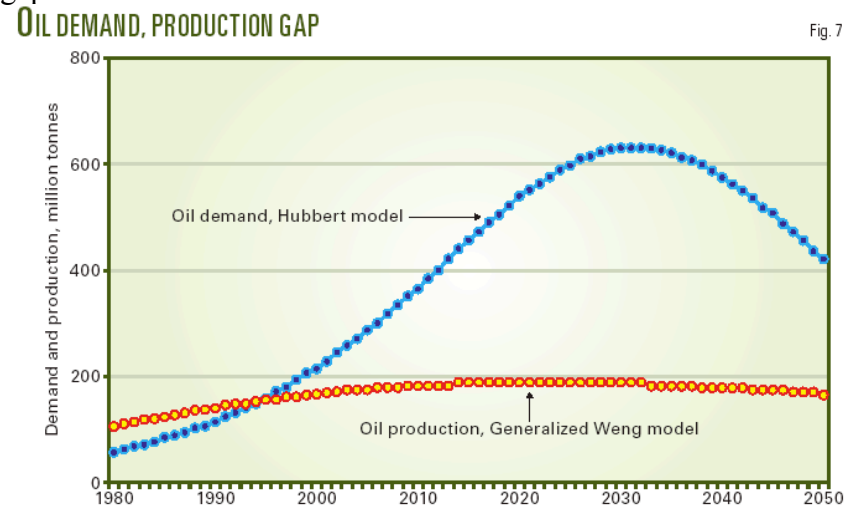
The oil consumption and oil production is compared, showing a large gap increasing from less than 4 Mb/d now to more than the double in 2030.



same graph in Mt.

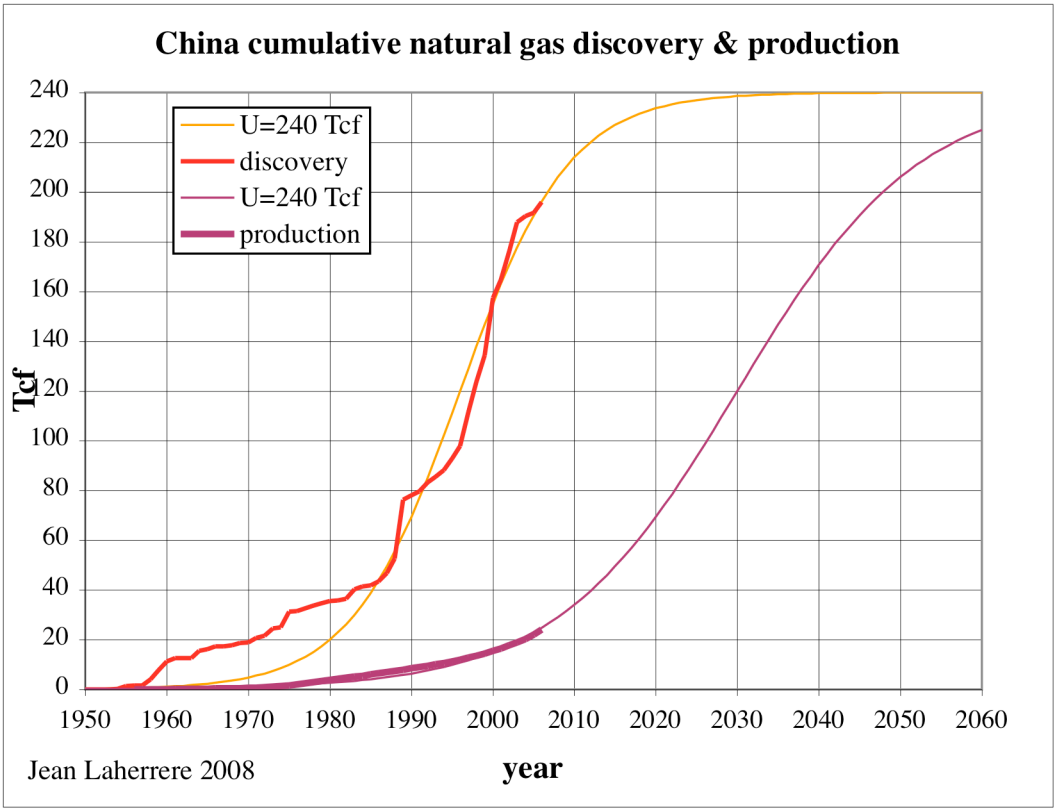


The comparison with your forecast in figure 7 shows a larger consumption and a larger production, but the gap in 2030 is about the same around 400 Mt.



I do not see why oil consumption has to follow a Hubbert model, it can be a bell-shape curve but how to guess h its ultimate it depends of the Chinese behavior with car. It seems that China wants to follow for cars the American way, building thousands of high ways ands millions of cars but it seems a whish full thinking, a dream difficult to achieve because the limits of the earth.

I have done the same work for natural gas


China cumulative natural gas discovery & production
240
220
200
180
160
140
120
100
80
60
40
20
0
Tcf
U=240 Tcf
discovery
U=240 Tcf
production
1950
1960
1970
1980
1990
2000
2010
2020
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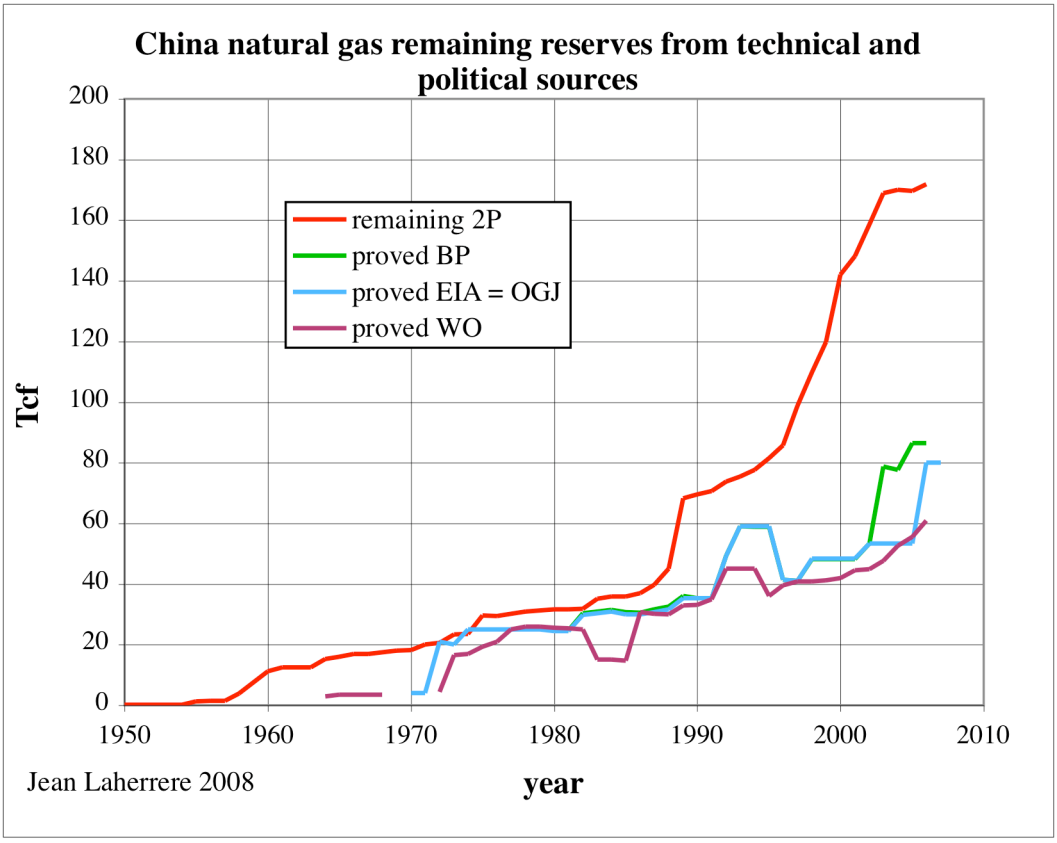
Jean Laherrere 2008
year


China natural gas remaining reserves from technical and political sources
200
180
160
140
120
100
80
60
40
20
0
Tcf
remaining 2P
proved BP
proved EIA = OGJ
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1950
1960
1970
1980
1990
2000
2010
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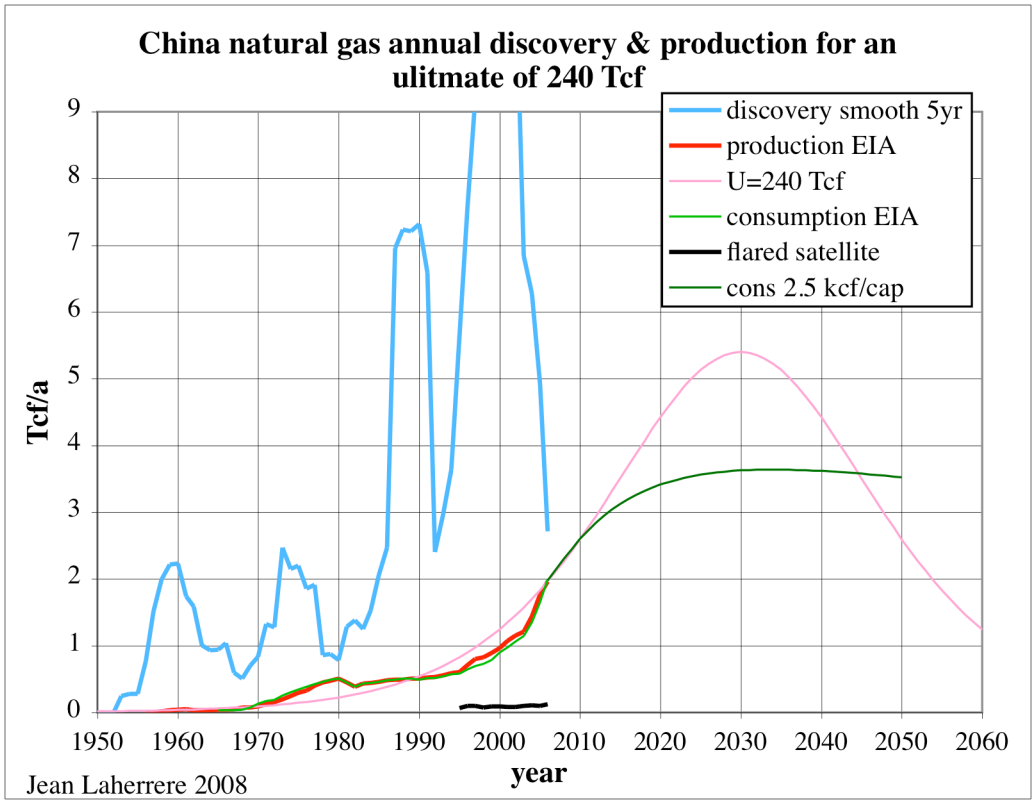
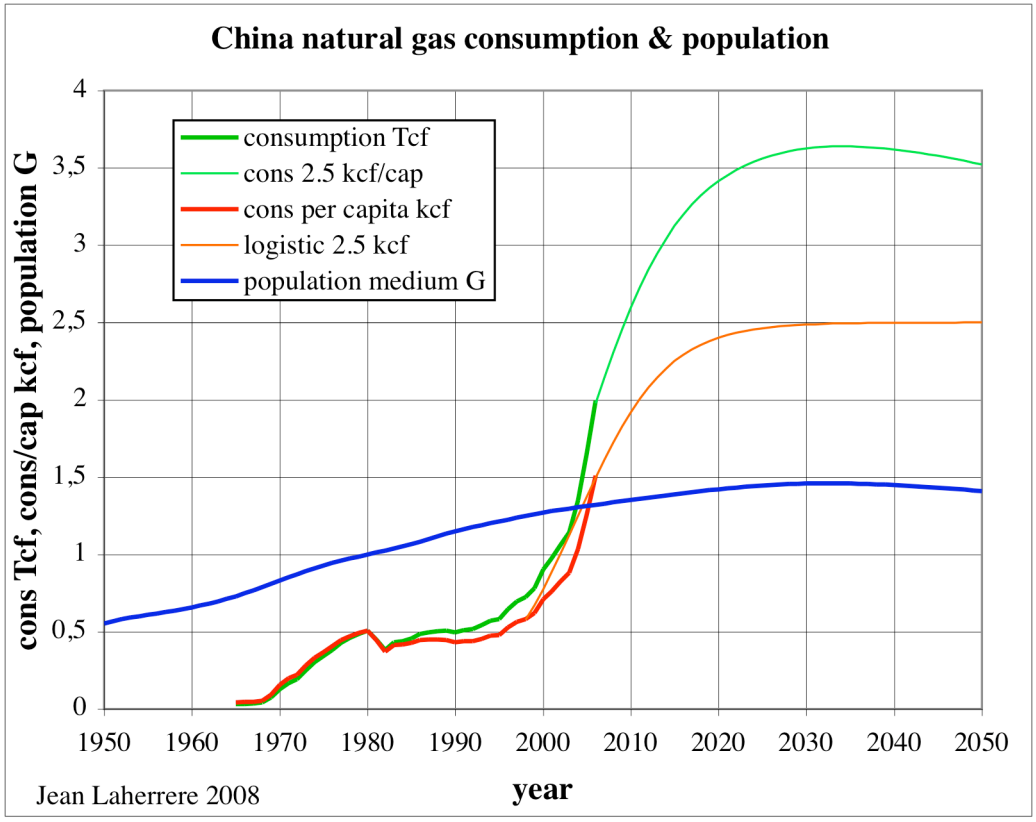
year





Best regards
Jean Laherrere

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Objet : My article published on "Oil & Gas Journal"
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Dear All:

I'm the teacher of China University of Petroleum, Beijing and I'm a member of ASPO-China. The attached is my article **"Peak oil models forecast China's oil supply, demand"** wiritten by my student Li Junchen. It has published on "Oil & Gas Journal" on January 14th, 2008. I hope it may be useful to the Peak oil research, so I send it to you. If you have any questions, we can have further communincation.

Best wishes.

Feng Lianyong
2008.1.15

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