The phosphorus peak

April 10th, 2007

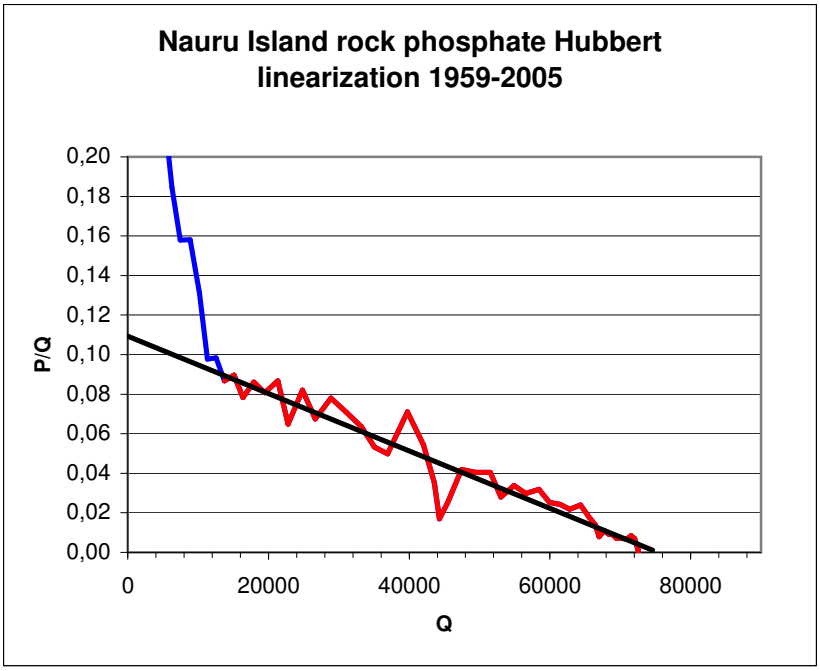
By Patrick Déry, physicist, energy, agriculture and environment analyst and consultant, Quebec, Canada

In his frightening book (Eating Fossil Fuels), Dale Allen Pfeiffer, write that our agriculture is oil-addicted like the rest of our society. But, beside that, farming needs a lot of mined phosphorus in diverse form (rock phosphate, superphosphate, triple superphosphate or ammonium phosphate) to produce our food. Agriculture is mined-phosphorus addicted too.

So we have the same problem in phosphorus that in oil: a phosphorus peak. Is it possible to use a tool like Hubbert Linearization (H-L) to evaluate the future production of rock phosphate? This is what I have tried to do with some success.

I have used data from United States Geological Survey (rock phosphate production historical data series) and done a H-L linearization for United States and World rock phosphate production. Results were stunning. The theoretical logistic curve fit almost perfectly with the real data curve. I found that we have already past the phosphate peak for United States (1988) and for the World (1989).

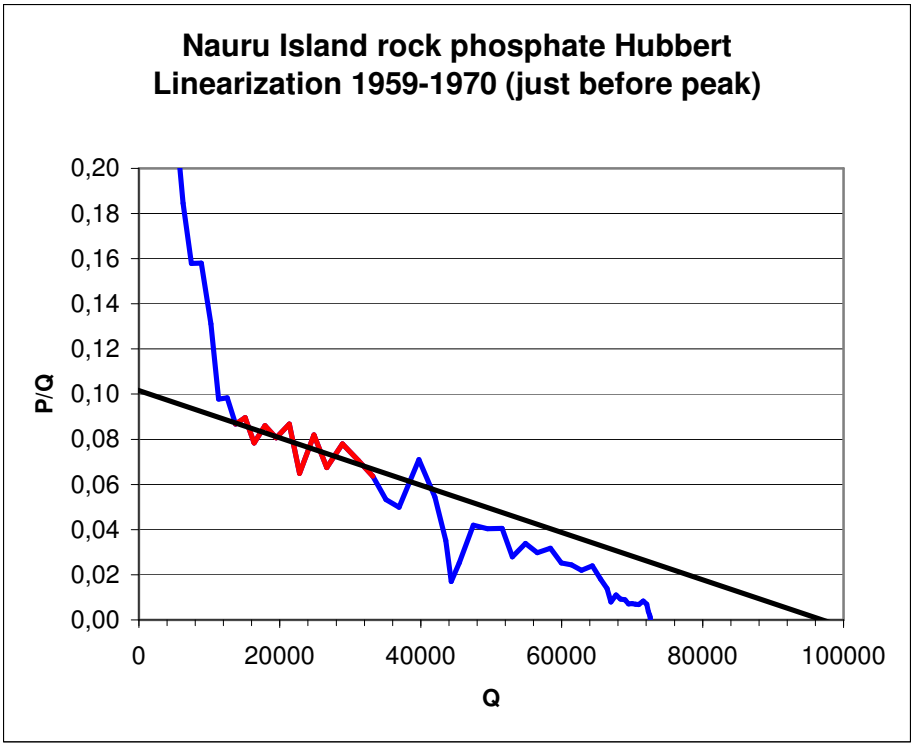
But those results were too perfect for me, so I decided to look for an example of an almost depleted region of production of rock phosphate, like it is the case of United Stated for oil. After some searching, I found a small island in the South Pacific called Nauru who appears to be an ideal case for my purpose. The Nauru Island is 21 km² with only one economic resource (beside to be a fiscal paradise!): rock phosphate. This resource is almost entirely depleted since 2005.

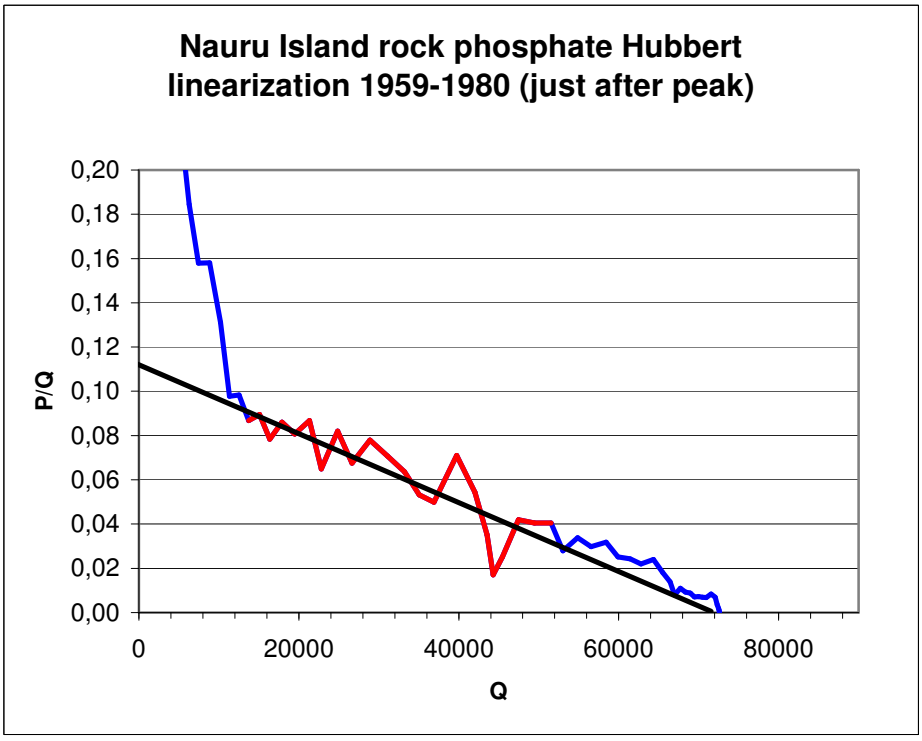


To begin with, I have made a Hubbert Linearization with the stabilised data (linear trends since 1959)and found and Ultimate Recovery Reserves (URR) equivalent of 77 000 kT and a peak of rock phosphate production in 1973.

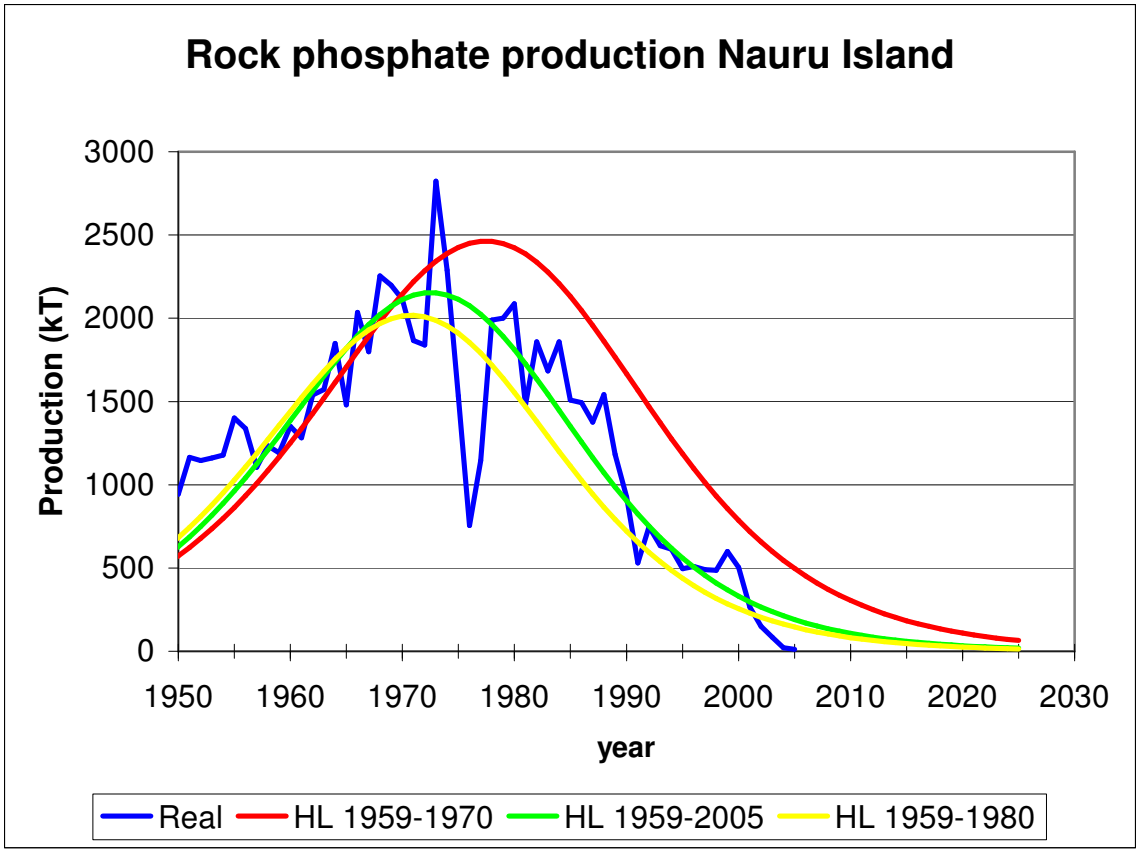
Looking at the results I have got, I have asked myself a question : could it be possible to predict the URR and the profile of future production just before the peak or just after? To get an answer, I have used the data from 1959 to 1970 (just before peak) and 1959 to 1980 (just after peak). The results were :

- Just before peak : URR = 97 000 kT; peak date: 1978
- Just after the peak : URR = 72 000 kT; peak date 1971





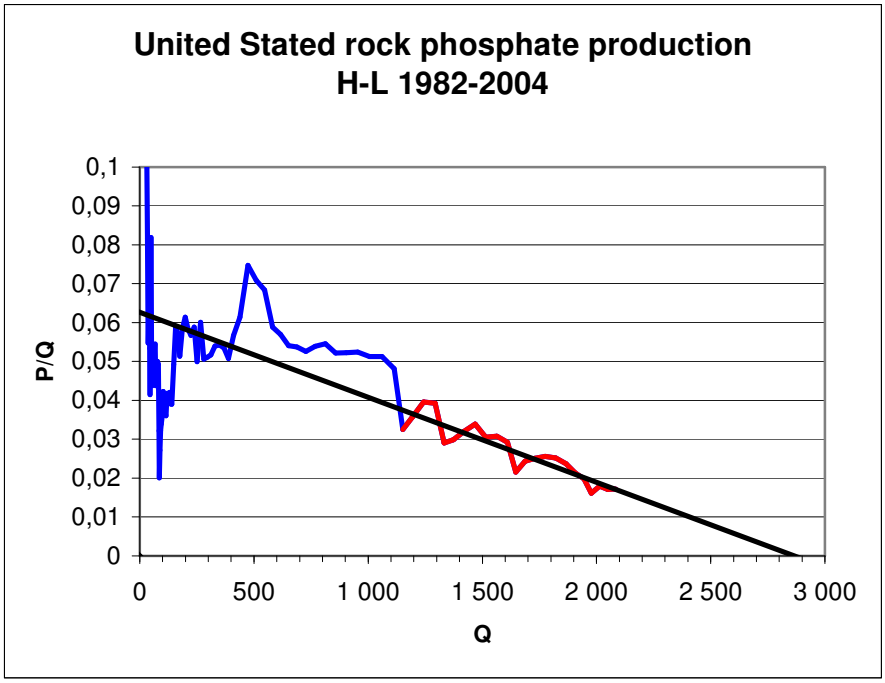
If we calculate to obtain production curves for all these scenarios and put everything on the same graph with real data, we obtain this:

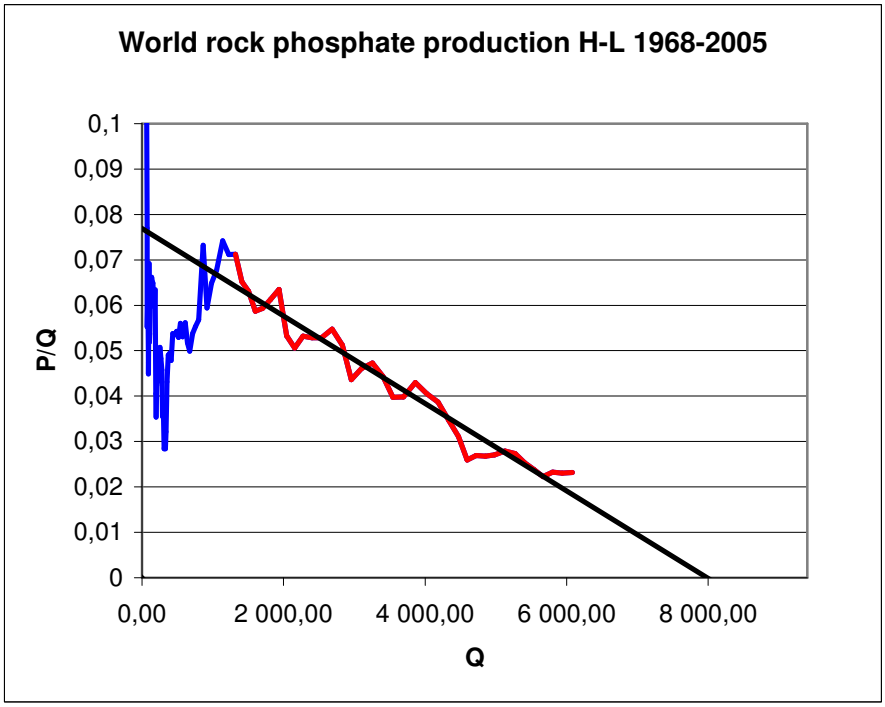


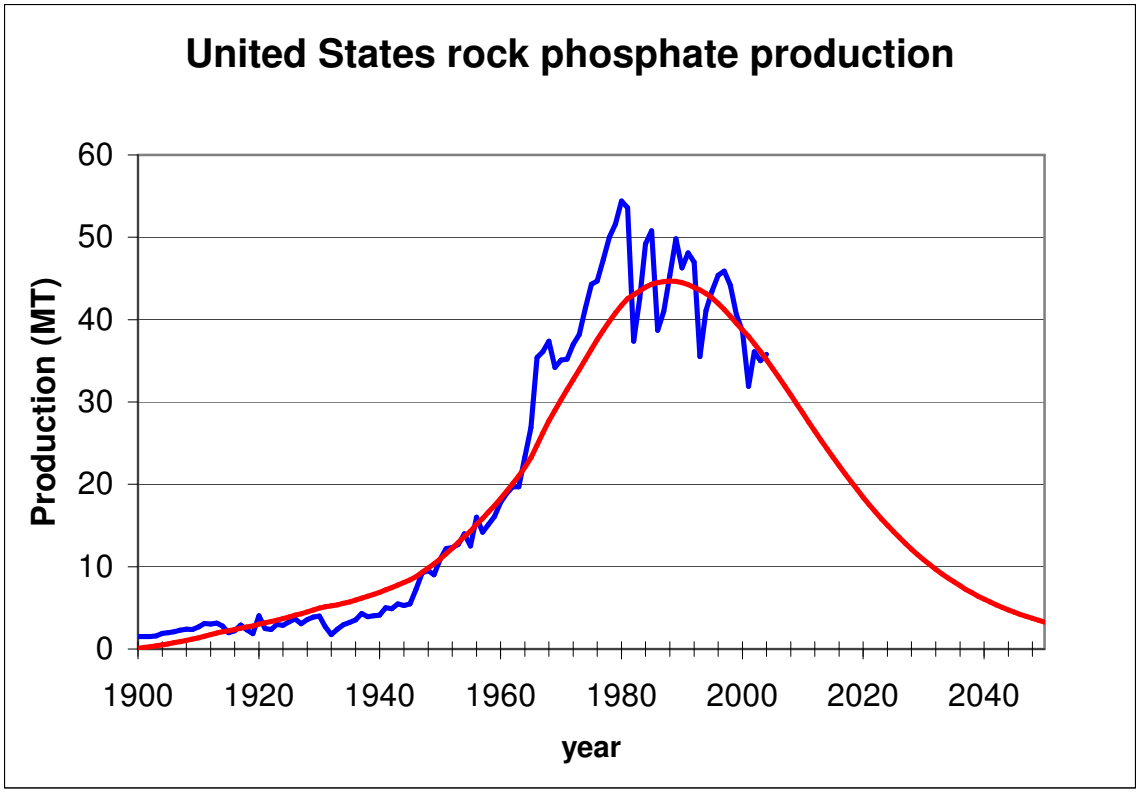
We see that the H-L just before peak, with this data set, exaggerated the URR (+26%) but the peak date (1978) was not so different from the real peak date (1973). It's the contrary for a H-L just after peak: URR little smaller (-6,5%) and a peak date in 1971.

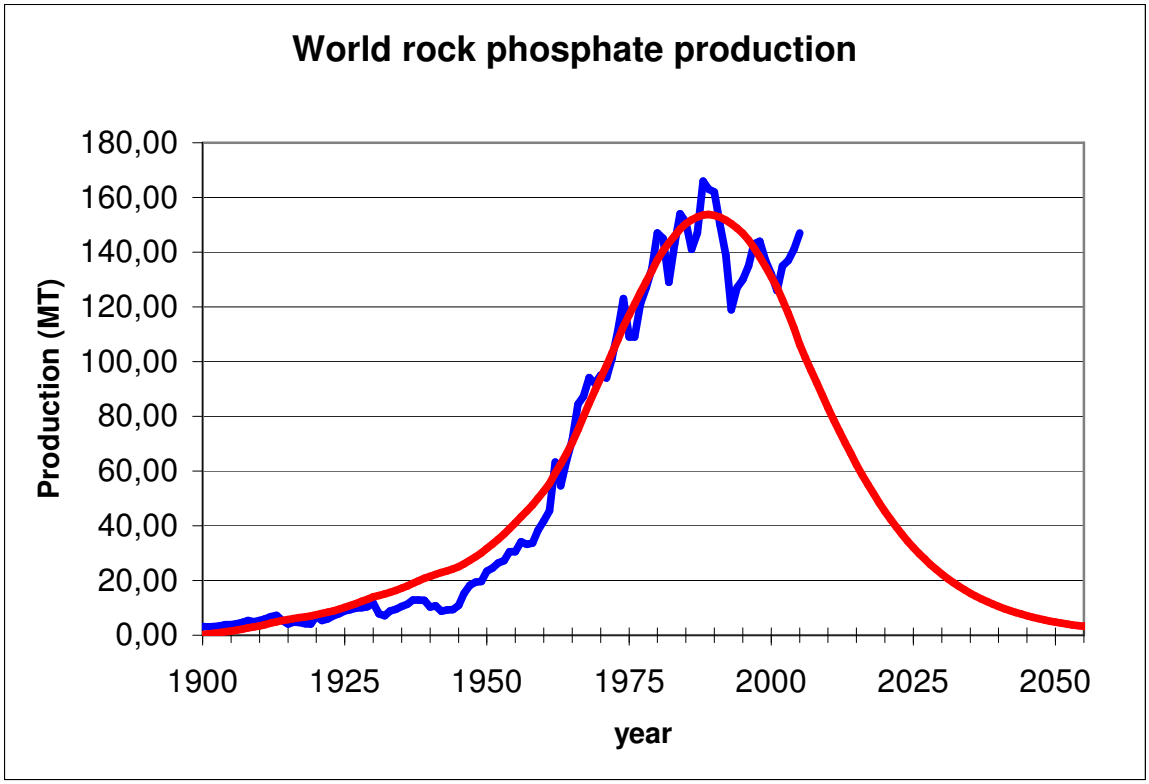
After this small test with Nauru Island, I felt more confident with my precedent results of a world peak of rock phosphate production in 1989 and a United States peak in 1988. And I'm also more confident to present the results.

For the United States, I have used data from 1982 to 2004 to found an URR of 2850 MT. For the world, I have used data from 1968 to 2005 to found an URR of 8000 MT.

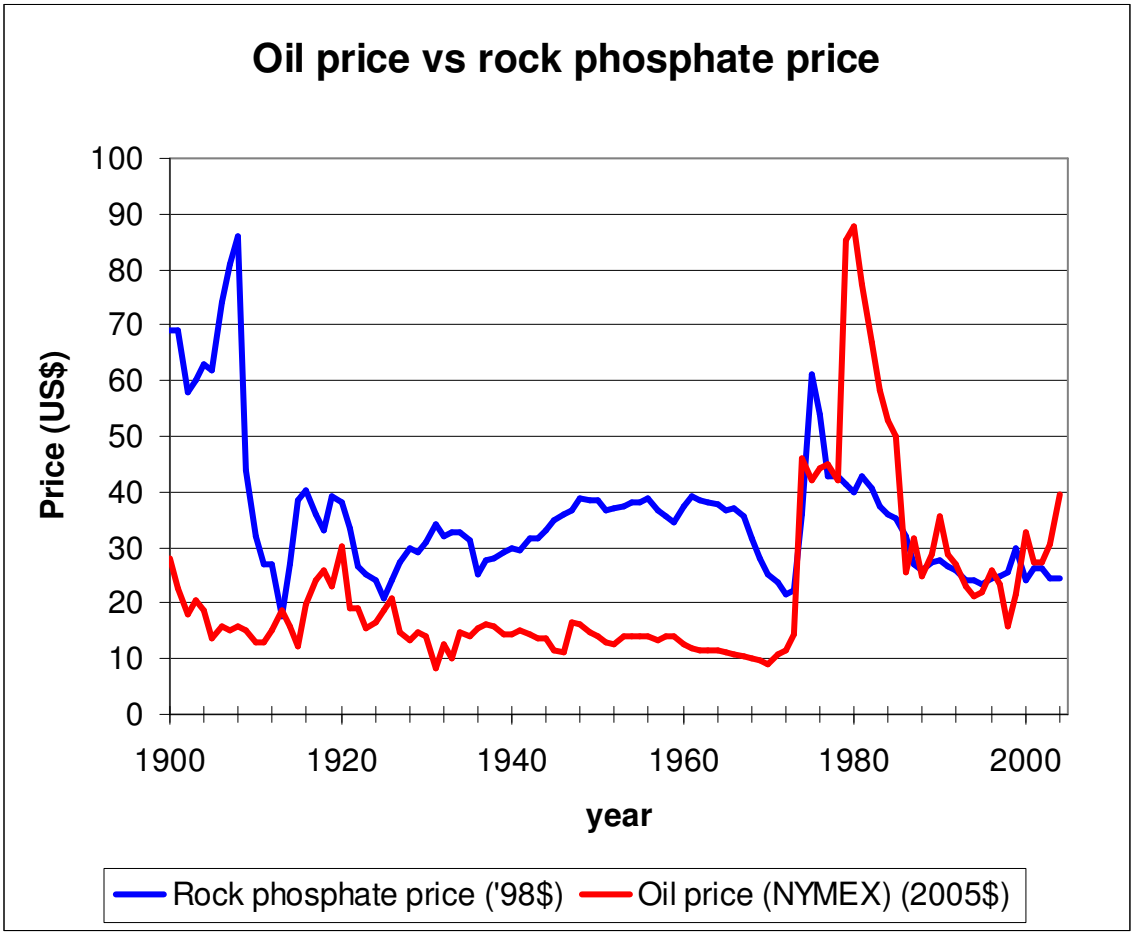

United Stated rock phosphate production
H-L 1982-2004
P/Q
0,1
0,09
0,08
0,07
0,06
0,05
0,04
0,03
0,02
0,01
0
0
500
1 000
1 500
2 000
2 500
3 000
Q


World rock phosphate production H-L 1968-2005
P/Q
0,1
0,09
0,08
0,07
0,06
0,05
0,04
0,03
0,02
0,01
0
0,00
2 000,00
4 000,00
6 000,00
8 000,00
Q


United States rock phosphate production
Production (MT)
60
50
40
30
20
10
0
1900
1920
1940
1960
1980
2000
2020
2040
year


World rock phosphate production
Production (MT)
180,00
160,00
140,00
120,00
100,00
80,00
60,00
40,00
20,00
0,00
1900
1925
1950
1975
2000
2025
2050
year

So we can see from the precedent graph that we are probably on a world decline of rock phosphate production. The kind of phosphate we talk about is commercial phosphate (26-34% of P2O5). There is others reserves of rock phosphate with less concentration of P2O5 but, like tar sand for oil, it is more costly to produce economically, energetically and environmentally speaking. I have also compared the price of oil and rock phosphate and it's seem that there a correlation between the two but not like other commodities (gold, silver, aluminum…).



United States Geological Survey (USGS) wrote in its publications : "There are no substitutes for phosphorus in agriculture." So, with the peak oil, we have another problem to solve in agriculture: the phosphorus peak. The only solution is to recreate a cycle of nutrients, eg returning animal (including human) manure on cultivated soil like asian people have done in the not so far past (F.H. King 1911). (See also in Energy Bulletin "Toilets vs Life as we know it" by Joe Anderson)

References:

F.H. King, "Farmers of forty centuries: organic farming in China, Korea and Japan", Dover Publications, NY, 1911 (ed. 2004)

J.C. Jenkins, “The humanure handbook”, Jenkins Publishing, 1994

D.A. Pfeiffer, “Eating fossil fuels, oil, food and the coming crisis in agriculture”, New Society Publisher, 2006.

A. Duncan Brown, “Feed or Feedback: agriculture, population dynamics and the state of the planet”, International Books, 2003.

Gunther, Folke, “Vulnerability in agriculture: energy use, structure and energy futures”, presented at the INES conference, THK, Stockholm, 2000.

B.Gumbo, H.H.G. Savenije and P.Kelderman, 2002. Ecologising Societal Metabolism: the Case of Phosphorus. In: Proc 3rd Int Conf Environmental Management. 27-30 August 2002.

Steen, P. 1998. Phosphorus Availability in the 21st century: management of a non renewable resource. Phosphorus and Potassium