



HC Problems & Nature Principles

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Foreword



The understanding of:

- **Energy problems,**
- **Peak oil production and**
- **HC remaining reserves**

is based on Nature Principles, which allow the interpretation of HC Data and so advance several conjectures.



Part I

HC Problems Review

HC Problems

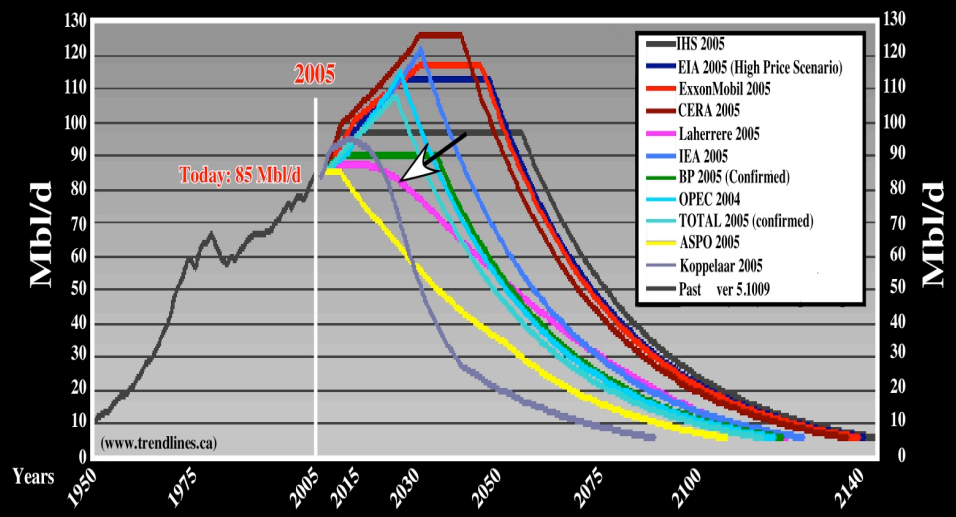
1) At the end 2005, the amount of liquid hydrocarbons produced since 1859 is ($\pm 1-2\%$) 1.000 Gbls (1.000 billion barrels).

2) Likely, the remaining reserves are:

- 1.000 Gbls of oil,
- 500 Gbls of extra-heavy,
- 250 Gbls of liquids,
- 250 Gbls of refining technology.

Peak Oil Depletion

Trend lines, scenarios 2005



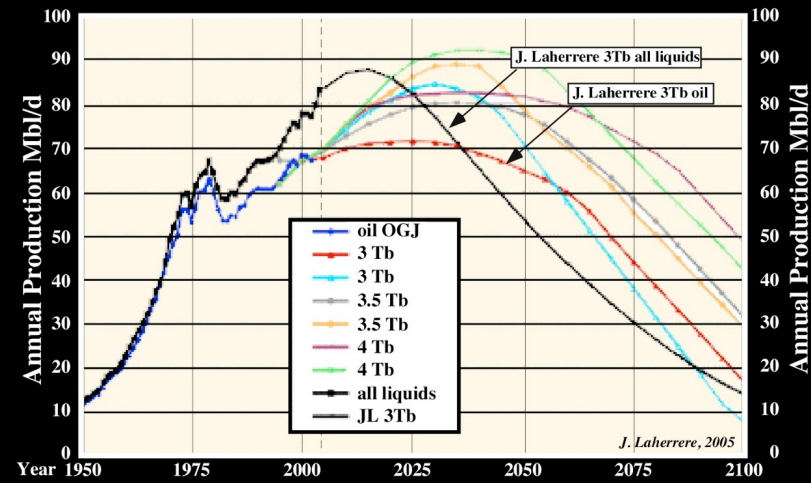
Our prediction (in purple) is slightly optimistic than ASPO 2005 (in yellow), but largely pessimistic when compared with the predictions of conventional petroleum-related organisations, such as IHS, EIA, BP, Total, OPEC, etc.

HC Problems

- 3) In early 2005, estimated global oil demand was forecast to reach 86 Mbl/d (millions barrels a day) or more by the end of the year. Demand increases had exceeded forecasts each year from 2002 to 2004.

- 4) Sooner or later, the worldwide use of oil must peak, because oil, like the other two fossil fuels, coal and natural gas, is non-renewable.

Oil Production Forecast (Salvador, A. vs Laherrere, J.)



A. Salvador's recent paper is quite optimistic in relation to our prediction. However, we believe that our data is technical data and so less influenced by politics whether of Governments or Oil companies. Notice that our all liquids and oil curves are made for a 3 Tb (3.000 Gbl) of ultime reserves.

HC Problems

- 5) The main reason that many oil experts have scoffed at claims that the peak oil might occur sooner than later is their belief in the superabundance of Saudi Arabia's oil resources.
- 6) Development is now underway on a number of giant oil fields around the world (Kasakhstan, Gulf of Mexico, West Africa), but none of these projects is expected to produce in excess of 200-250 kbl/d.

HC Problems

- 7) The volume of water produced from the world's oil fields is now estimated to exceed 200 Mbl/d, nearly 3x the volume of the oil. Oil wells in US produce more than 7 bls of water for each barrel of oil. *(M. Simmons, 2005)*

- 8) The annual cost to US producers for disposing of this produced water is USA \$5-10 G. Worldwide, the cost to handle superfluous water is estimated to be around USA \$40 G (billions) *(M. Simmons, 2005)*

**In addition,
please don't forget what they say:**

(Y. Cochet, 2005)

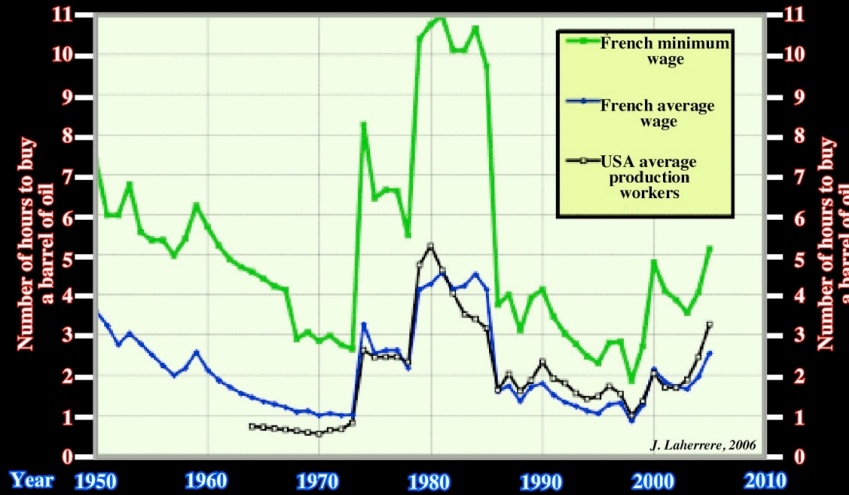
- ✓ A barrel of oil has a potential energy equivalent to 35.000 hours of human work.
- ✓ The production price of human mechanic work is USA \$200 the barrel (taking into account European gasoline taxation).
- ✓ Using humans to do the same work (USA \$20/hour), the price will be roughly \$200.000, i.e. 1000x more expensive than oil + engine.

(J. Laherrere, 2006)

- ✓ By the end of 2005, an European worker (minimum wage) should work 4-5 hours to buy a barrel of oil, while an American worker should just work 2-3 hours to buy it .
- ✓ In 1980, the same European worker should work eleven (11) hours to buy a barrel of oil and the American four (4). In other words, beginning 2006, a barrel of oil was roughly 2.5 times less expensive than in 1980 (see next plate).

HC Problems

Price of Oil in Working Hours

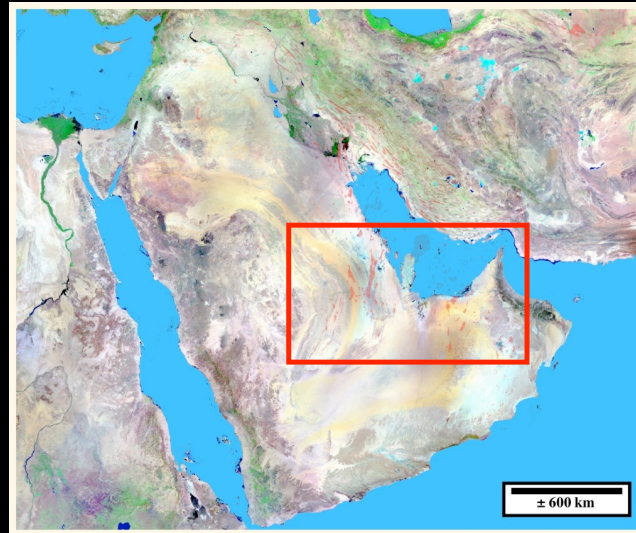


This plot indicates the price of the oil (number of working hours need to buy a barrel of oil) drops since 1950 till the 1972-1973. Then, it jumped to reach a maximum during the 80s. Then abruptly, the price came down till 1998 to start rising again till today.

(M. Simmons, 2005)

- ✓ **The most urgent energy question for the world, as oil consumption fast approaches 85 Mb/d, involve the sustainability of Saudi Arabia's oil production.**
- ✓ **Saudi Arabia clearly seems to be nearing or is at its peak output and cannot materially grow its oil production. In all probability, output peaked in 1981 at an unsustainable level of about 10.5 Mbl/d.**

Middle East Oil Fields

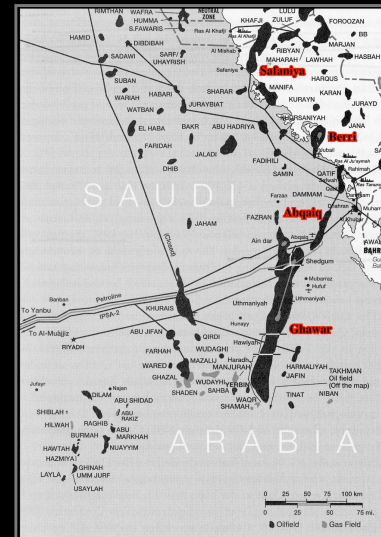


According to Campbell (2002), the total Middle East reserves are: (i) Discovered Reserves around 758 Gbl, (ii) to Yet to Find 47 Gbl and (iii) Ultimate 805 Gbl. Such values represent respectively 43%, 33% and 42% of the total World Reserves. Saudi Arabia represents roughly 40% of Middle East reserves.

Saudi Arabia Oil Fields Dynasty

Saudi Arabia represents roughly 40% of Middle East reserves. They are mainly associated with four major fields:

- (i) the “King” **Ghawar**,
- (ii) the “Queen” **Safaniya**,
- (iii) the “Dowager Queen” **Abqaiq** and
- (iv) the “Prince” **Berri**.



In the majority of hydrocarbon basins a hierarchy of oil fields is often recognized: (i) a King, (ii) a Queen or perhaps two or three, (iii) a handfull of Earls or Lords (5 or 10) and (iv) a larger number of Commoners or Peasants. Ghawar, King of all Kings, discovered in 1948 and onstream in 1952, is the largest oil field in the world. It has now produced over 55 billion barrels. Its oil accounted for 55 to 65% of Saudi Arabia’s total production.

**Ignoring the risks posed
by the oil pick of Saudi
Arabia any longer is
folly.**



I don't see
anything



HC Problems

Applying the **Basic Principles** ruling the **Nature** on the available data base:

- OPEC,
- OGJ,
- Petroconsultants,
- IHS,
- BP review,
- World Oil,
- USDOE/EIA

the following conjectures on Exploration / Production can be postulated:

Conjectures

Conjecture 1:

Publishing reserves is a political act.
In addition, there are several category of reserves

Conjecture: 2

Field Growth corresponds mainly to bad practices of reserves reporting.

Conjecture 3:

Technological progress lead to faster and cheaper production, but has not much impact on conventional reserves.
Technological progress is needed for unconventional resources.

Conjecture 4:

Oil Price increase will raise unconventional resources, not yet listed as reserves, but it does not increase conventional resources.

Conjectures

Conjecture 5:

Cheap Oil will peak soon in North Sea and in Non-OPEC countries. For the world, it peaks probably this year.

Conjecture 6:

Except in Eastern deep-water of South Atlantic margin, where large fields (± 0.5 Gb) are likely, **Future Short Term Reserves** are those that in past:

- ★ **Have been missed.**
- ★ **Have not been take into account.**

Conjecture 7:

Long Term Reserves will be chiefly associated with few foredeep, fold belts and subsalt traps, in which seismic data is difficult to acquire and often useless.

Conjecture 8:

Exploration requires a good data base and explorationists with an appropriate experience in **Pragmatic PHT Exploration** (**P**roblem, **H**ypothesis, **T**est)

HC Problems

**The oil production in the last 20 years
was estimated at roughly at 70 Mb/d:**

- 40 Mb/d from giant fields,
- 7 Mb/d from small fields,
- 12 Mb/d from new developed fields,
- 10 Mb/d from improved fields and
- 3 Mb/d from new discoveries.

The Oil Pyramid

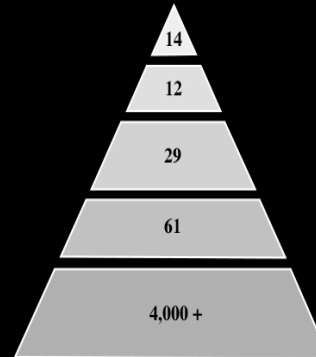
Average Field
Production
barrels/day

993,000
342,000
221,000
130,000
9,000

Total Contribution
of Fields (000 bpd)
% of World total

13,900 (20%)
4,100 (6%)
6,400 (9%)
7,900 (12%)
36,200 (53%)

Number of Fields



Field Output
barrels per day



Simmons & Company International, 2005

As illustrated, around 100 fields produce 50% of the reserves consumed per day. More than 95 percent of the fields produce less than 10,000 barrel per day and less of 1% produce more than 500,000 barrels per day. In other words, as said previously, in the world there are there 14 Kings (Ghawar being the King of Kings), 40 Queens, 61 Earls or Lords and quite a larger number (> 4,000) of Commoners or Peasants.

Giant Oilfields

Age & Supply Contribution in 2000

Simmons & Company International, 2005

Field Size by Production Volume	Number of Fields	Total Production (barrels per day)	Decade of Discovery					
			Pre-1950s	1950s	1960s	1970s	1980s	1990s
>1,000,000	4	8,000,000	2	1	0	1	0	0
500,000/1,000,000	10	5,900,000	2	3	3	1	1	0
300,000/500,000	12	4,100,000	3	1	6	1	1	0
200,000/300,000	29	6,450,000	8	4	6	9	1	1
100,000/200,000	61	7,900,000	5	8	13	13	11	11
Total	116	32,350,000	20	17	28	25	14	12

From the 116 fields producing around 50% of the world consumption per day, that is to say, 33 Mb/d, the large majority was found before the 70s. Also, it is quite evident that since long time (1950s), any field, with a daily production higher than 1 Mb/d, has been found. In other words, (i) since the 50s, all petroleum basins were recognized and they can be considered as mature, or overmature at the exploration standpoint. Since 90s, with exception of deepwater South Atlantic Margins were few fields with a potential of 200.000/300.000 barrels per day have been found, the picture stays the same.



Part II

Nature Principles Review

Nature is ruled by some basic Principles

- Inequality
- Self-Similarity
- Fractal Distribution
- Cyclicity
- Finiteness
- Gravitation
- Life
- Determinism & Probabilism
- Symmetry



**Equality may exist at
the starting line, but at
the end there is usually
only a winner**



Inequality is the rule in Nature



Inequality

Consumption of Primary Energy (CPE)

Region	CPE Gtep	Population G	CPE/capita tep
North America	2,5	0,31	8,1
Japon/Australia/New Zelande	0,7	0,15	4,7
Western Europe	1,8	0,52	3,5
Ex-URSS	1,1	0,35	3,4
Middle East	0,4	0,17	2,4
South America	0,6	0,52	1,2
China	1,1	1,26	1
Asia (without China)	0,8	0,96	0,8
Africa	0,5	0,79	0,6
India	0,5	1	0,5
World	10	6	1,7

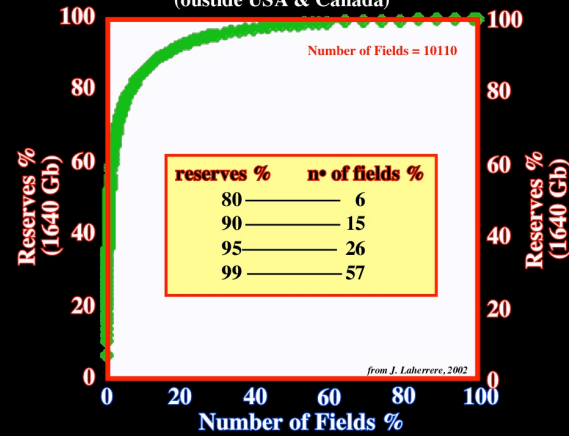
Rapport 2000 du Conseil Mondial de l'Énergie

On this subject, it is quite interesting to notice that US has 5% of the world population, spends 25% of the energy in world, has 40% of the autos in the world, represents 60% of the world commerce and has 70% of the lawyers in the world.

Inequality

Reserves & Number of Fields

(outside USA & Canada)

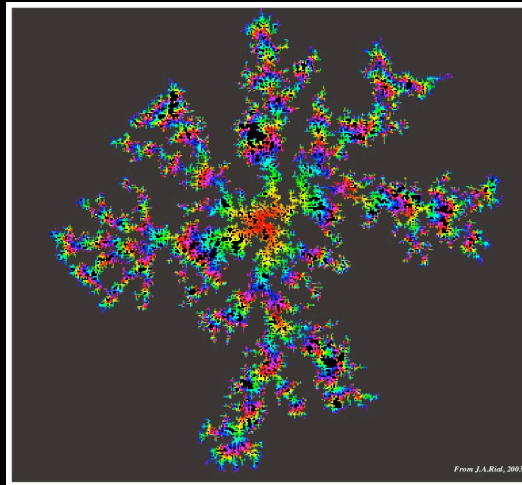


The worldwide oil field hierarchy is easily recognised on this plot. Ghawar, the King or kings, with five (5) others kings and 15 queens represent 90% of world reserves outside USA and Canada. The Earls and Lords are around 90 and they contribute to 9% of the reserves. The last 1% comes from more than 4000 Commoners and Peasants. In other way, inequality is a characteristic of oil and gas fields.

**Nature is characterized
by self-similarity. Natural
objects have a fractal
geometry**



A part is similar to the whole

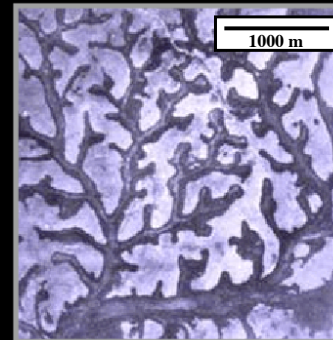
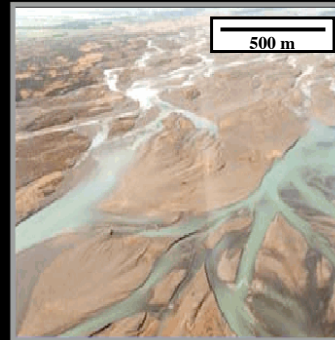


Simulation of crystal growth. The fine structure of the “crystal” is self-similar. A part is similar to the whole. However, it is relevant here to point out that the sum of the part is not equal to the whole. The whole is more than the sum of the parts and its characteristics cannot be approached by the study of the parts in isolation.

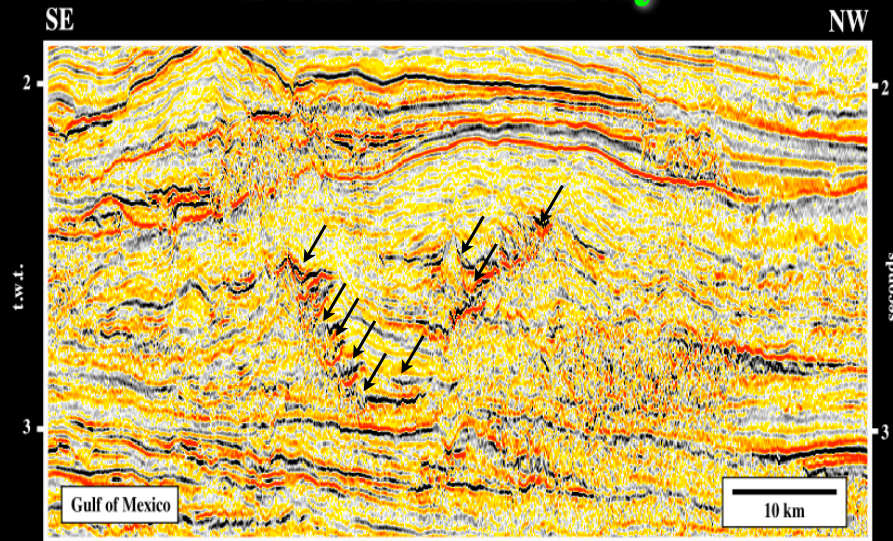


A natural object, or geometric figure, is fractal when:

- ✓ Its parts have the same shape (structure), in spite of their scale or deformation.
- ✓ Its shape is either irregular, interrupted or fragmented independently the scale of observation.
- ✓ It contains distinctive elements, which scales are very varied and covering a very wide range.

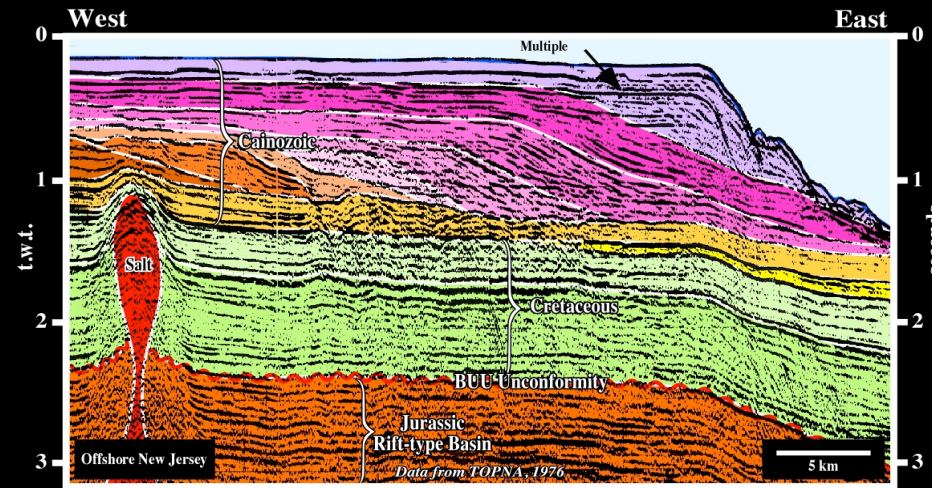


Self-similarity



On this line of Gulf of Mexico, self-similarity is paramount in turbidite depositional systems. Indeed, in slope fans, channel-levees complexes (whole) are composed by a multitude of parts with same shape and structure in spite of their small scales.

Geoscientists know a scale is necessary to interpret an outcrop or seismic line

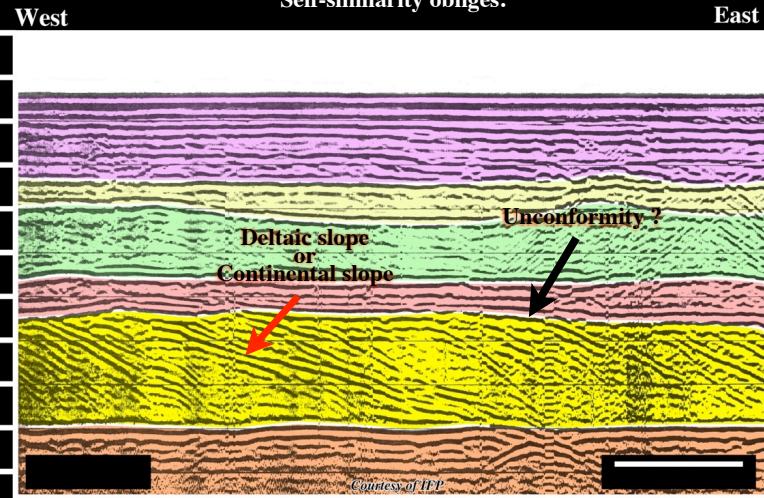


Without scales, orientation and location (outside of the geological setting) and the geological interpretation of a seismic line is meaningless, because self-similarity. Indeed, a slope delta is similar to a continental slope and to any offlap.

Self-similarity = Fractal

Geology is Scale Dependent

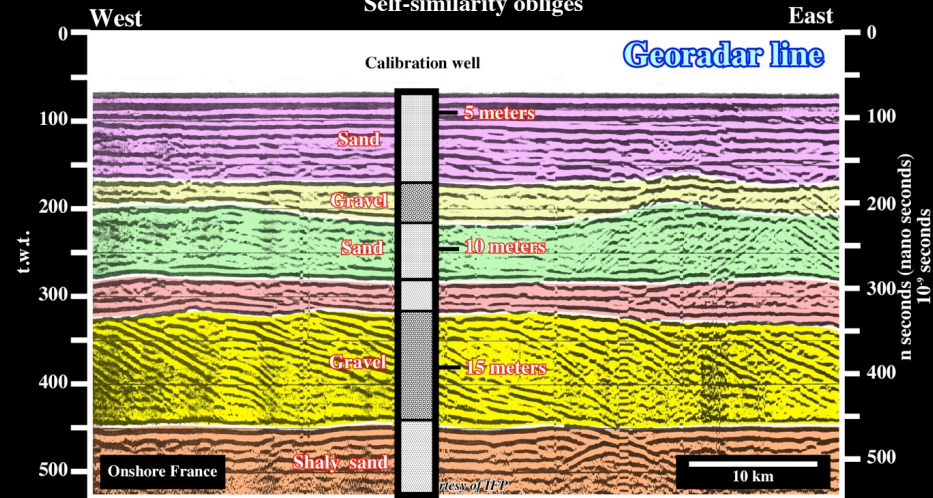
Interpretation requires a scale.
Self-similarity obliges.



As Geology is scale dependent, geological seismic interpretations cannot be performed without knowing the scales, as well as the global and regional settings. On this line, interpreters will be able to interpret the depositional inclined reflector. The reader is supposed to make a guess: shelf or slope downlaps?

Geology is Scale Dependent

Interpretation requires a scale
Self-similarity obliges



This line is a georadar line shot in onshore France (Pin Sec). The vertical scale is in nanoseconds. The interpretation was based in a calibration well, in which georadar velocities range from 0,08 to 0,13 ns. The depositional inclined reflectors are not associated to a deltaic or continental slope, but small oblique bedding planes (probably strandlines).



Fractal Distribution

(Parabolic)

Natural objects, or natural events, when listed in decreasing size and plotted on a log-log format with size against rank show a parabolic fractal distribution



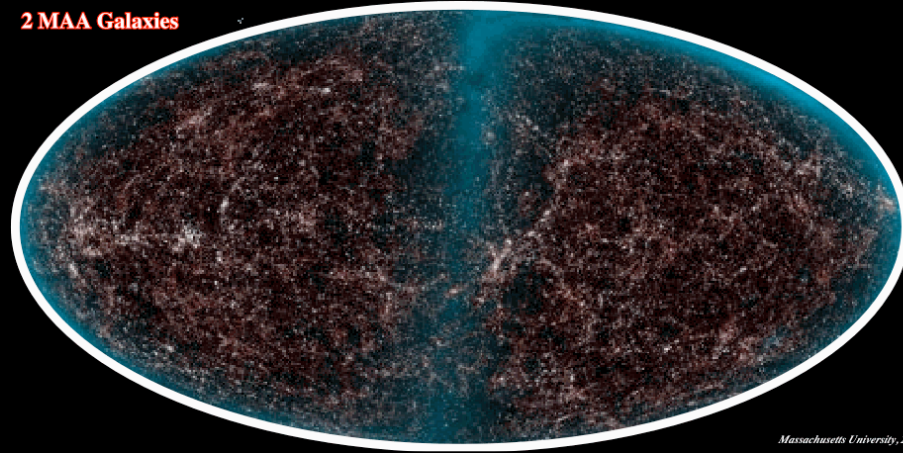
Fractal Distribution

- Galactic intensity,
- Town sizes,
- Reserves,
- Field sizes,
- HC accumulations within a given PS, etc.

have a fractal parabolic distribution.

Galactic Intensity

2 MAA Galaxies

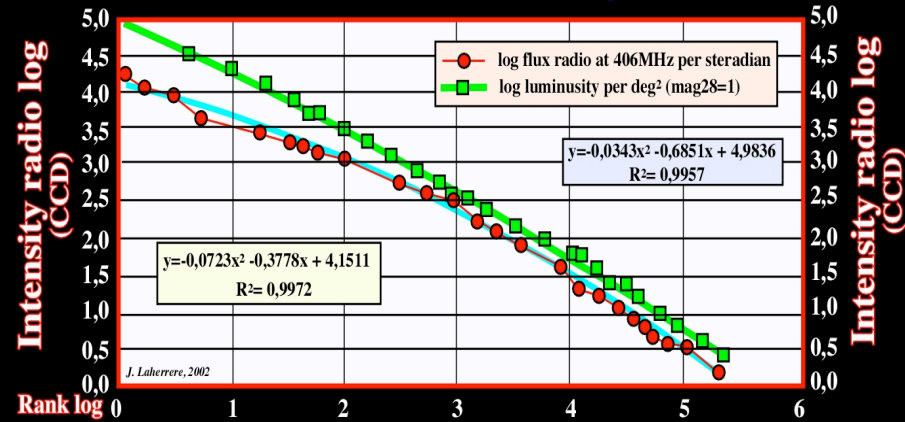


Massachusetts University, 2002

In this infrared view of the entire sky, blue represents close and bright stars in the Milky Way. It also reveals the distribution of the galaxies beyond the Milky Way, presenting galaxy clusters and super-clusters as filaments throughout the image. The galactic intensity (flux radio, luminosity) when listed in decreasing size and plotted on a log-log format, with size against rank, shows a parabolic fractal distribution, as illustrated next.

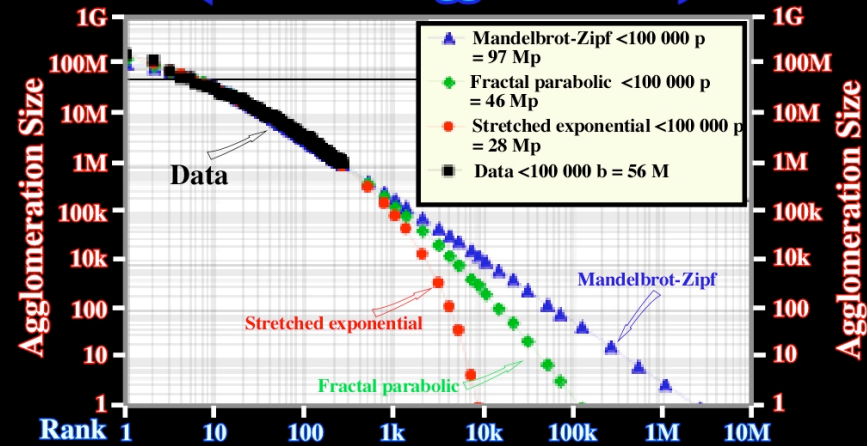
Fractal Distribution

Galactic Intensity



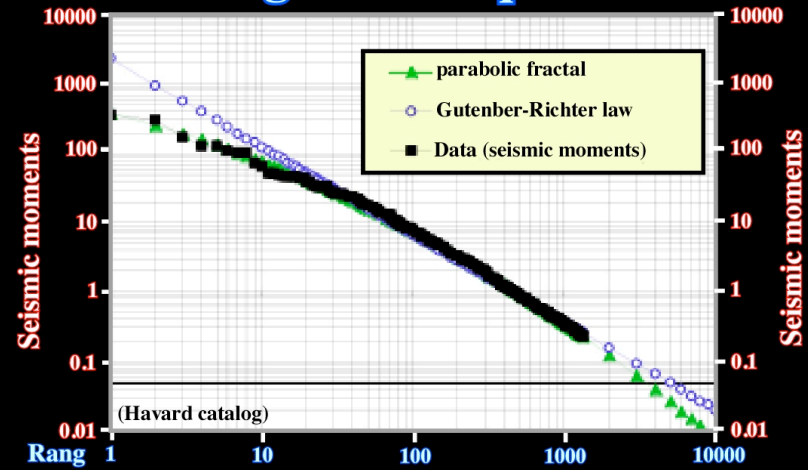
Indeed, as illustrated above, the galactic intensity (flux radio, luminosity) when listed in decreasing size (decreasing luminosity) and plotted on a log-log format, with size against rank, shows a fractal distribution. However, as illustrated next, several fractal parabolic curves can be considered.

Fractal Distribution (US Urban Agglomeration)



USA urban agglomeration were listed in decreasing size and plotted in a log-log display against rank. The data shows a fractal distribution. Several extrapolation are possible: (i) Mandelbrot-Zipf, (ii) Fractal parabolic and (iii) Stretched exponential. Perfect self-similarity is a power law or linear fractal in log-log display (size/rank). Imperfect similarity is a curved display. The simplest seems to be the parabolic fractal.

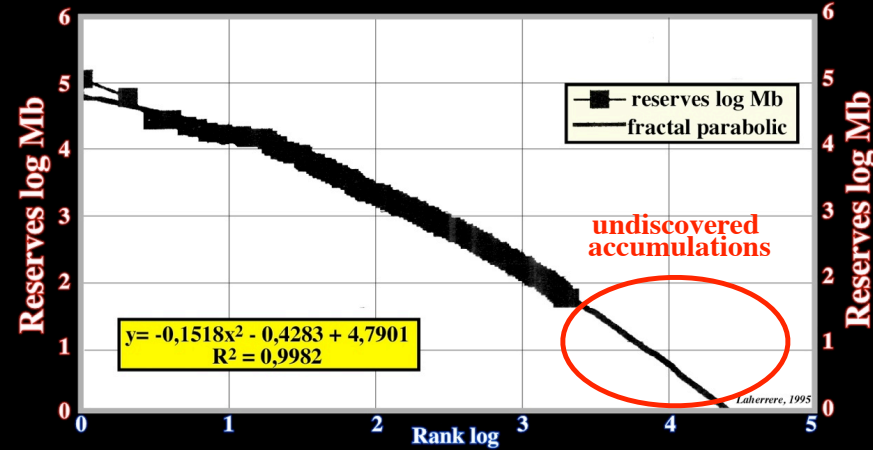
Fractal Parabolic Largest Earthquakes



It is evident that in this particular example the best fit is parabolic fractal, at least for small and medium ranks. Similarly, in basinal turbidite depositional systems, the plot of thickness of the lobes against rank, on a log-log format, shows a parabolic fractal distribution.

Fractal Parabolic

Reserves

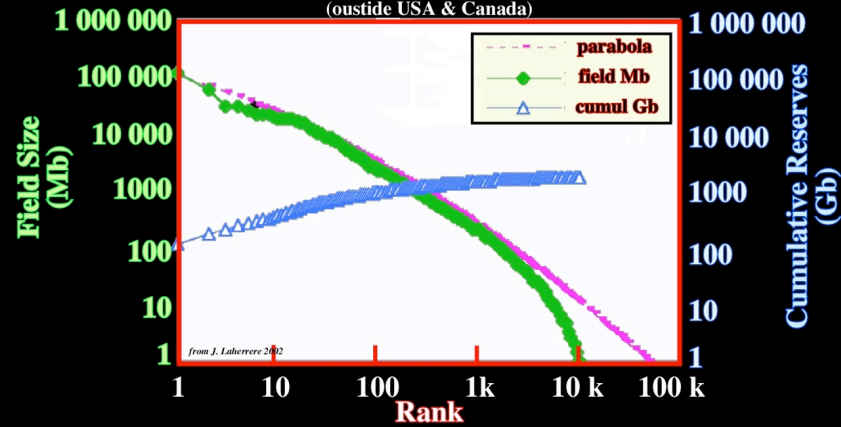


Plotting in a log-log display, reserves versus rank shows also a fractal distribution. The fractal parabolic curve allows geoscientists to predict, roughly, undiscovered accumulations. Such a distribution, which also observed in single petroleum basins allows to determine the degree of maturation of exploration.

Fractal Parabolic

Oil Fields Size

(outside USA & Canada)



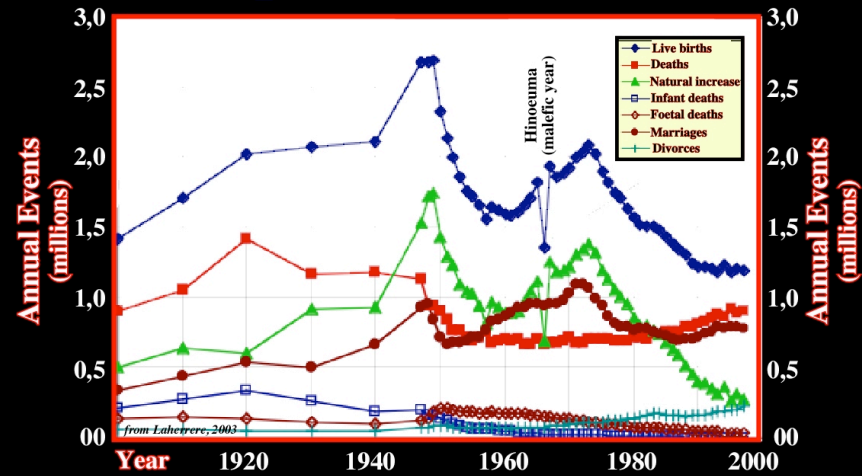
The size plotted versus rank shows a fractal distribution (in green) that fits, not very badly, with the fractal parabolic curve distribution (in pink). The cumulative reserves curve (in blue) strongly suggest ultimate reserves around 2-3 Gb. Remind, that, as said previously, more than 1 Gb have already been produced, so probably, we have already spent half, or very near, of the world reserves.

**All natural events
can be depicted
by one or several cycles**



Cyclicality

Japan Annual Events



Live births, deaths, natural increase, infant deaths, foetal deaths, marriages, divorces, that is to say, natural events are cyclic. In Japan annual events, an anomaly must be taken into account, in 1968/1970, the Hinocuma or the malefic year.

Cyclicality



Nothing is eternal



What is born will die



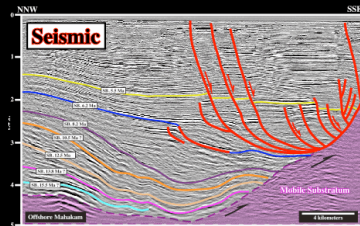
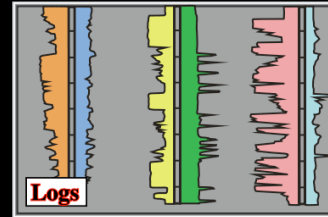
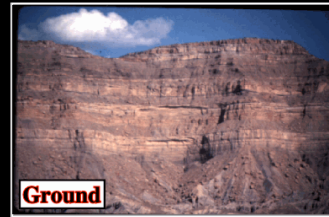
What goes up will come down



**Sun, earth, mankind, civilisation, etc.
will die.**

Cyclicality

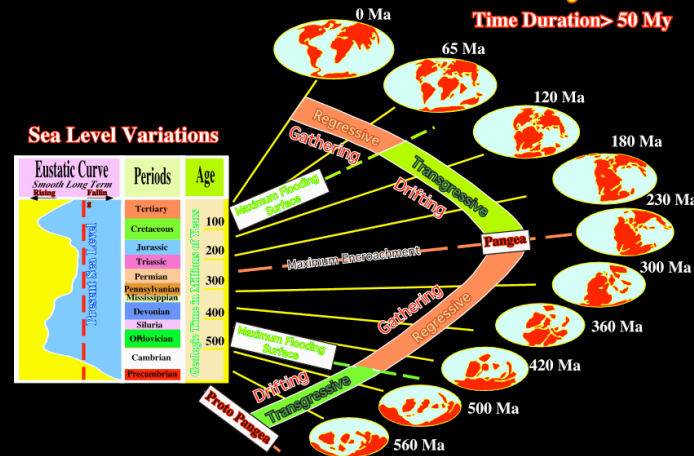
Depositional Systems are Cyclic



Since long time, geoscientists notice the cyclicality of deposition systems and tried to explain it. Admittedly, after Benoit de Maillet and Lavoisier, the majority of them assume that Eustasy, that is to say, sea level variations, is the mainly source of the cyclicality of the depositional systems.

Cyclicality

Continental Encroachment Cycles

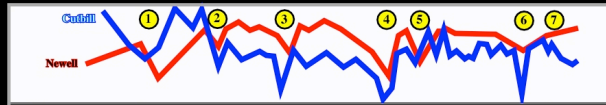


The Earth's history, at least since Phanerozoic (600 Ma), can be depicted as cyclic. After the gathering of the Proto-Pangea supercontinent, it broke in several continents, which dispersed to a maximum, by sea floor spreading, before gathered, again, to form the Pangea. Then, the Pangea broke up in several continents, which after dispersion are gathering to form a new supercontinent. These major geological cycles, recognized by Wilson Tuzco, are known as Wilson's cycles.

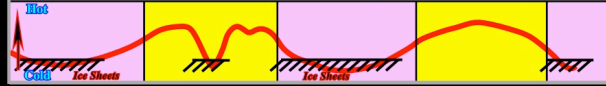
Cyclicality

Major Geologic Events are Cyclic

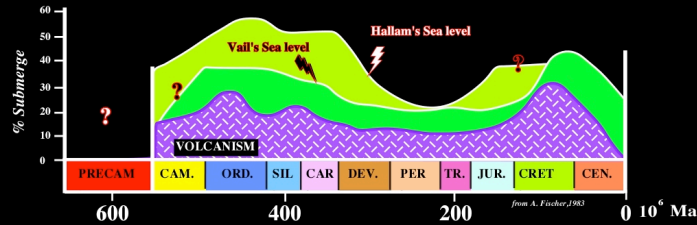
**BIOTIC
CRISES**



CLIMATE



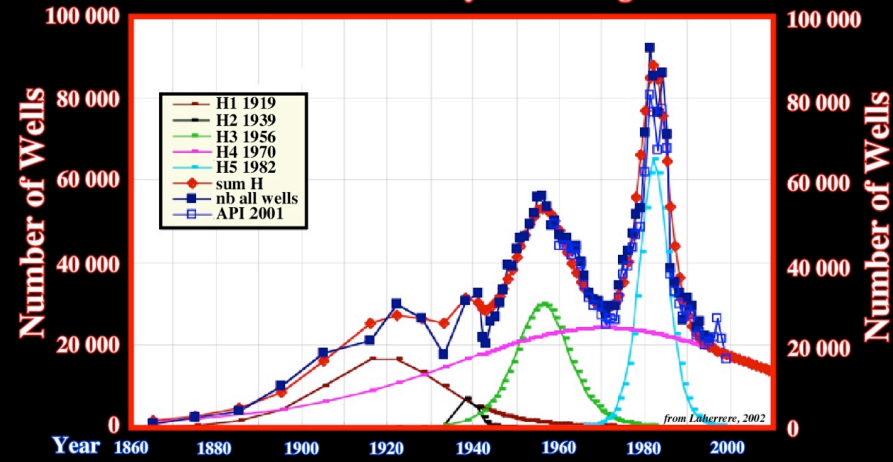
SEA LEVEL



The Plate Tectonics paradigm, which is a cyclic theory, explains quite well the correlation between major geologic events, which are interlinked and interconnected. Indeed, they cannot be understood in isolation. A systemic, or global approach, is required to understand the whole, which is much more than the sum of the parts. Detail studies can be fascinating, but, unfortunately, we learn from generalities.

Cyclicality

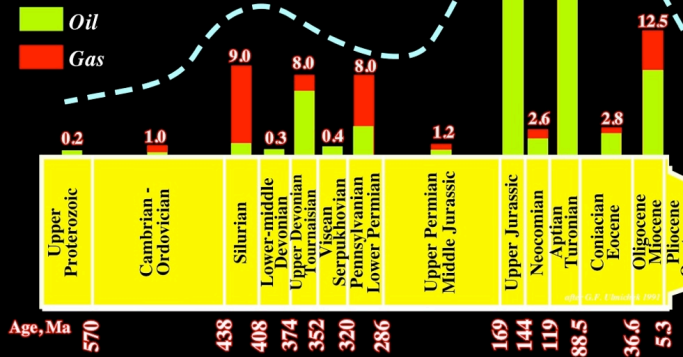
USA Drilling (all wells) with 5 Hubbert cycles modeling



The number of wells drilled in petroleum exploration, as all natural events, seems to be cyclic, as suggested by this plot (n° of wells drilled per year). Such a cyclicality can be due to demand problems, new plays (turbidite depositional systems), new technology (deepwater drilling or seismic acquisition), etc.

Cyclicality

Percent of world's original petroleum reserves (BOE) generated by source rocks of a stratigraphy interval



The stratigraphic distribution of the source rocks, as the majority of geological features, shows a sharp cyclicality, which is explained by Plate Tectonics. The marine source sources are associated with the 1st order eustatic highs, that is to say, Jurassic-Cretaceous and Cambrian-Silurian transgressions. Notice that Hercynian orogeny destroy a huge amount of hydrocarbons which are not taken into account in this plot.

**Infinite, as perpetual
growth, does not exist.
Earth, as well Universe,
is limited**



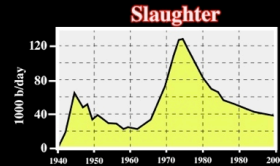
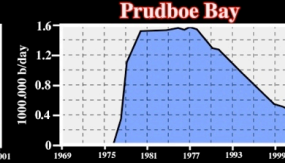
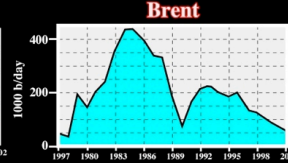
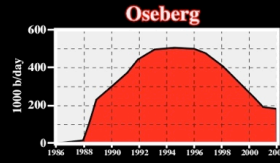
Finiteness

In the Nature, there is no permanent growth, that is to say, all which is born, has to die, or all which rises, has to come down again.

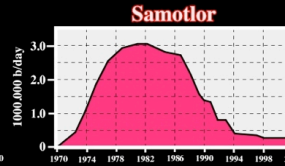
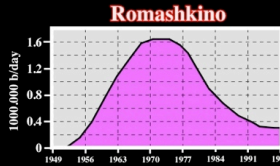
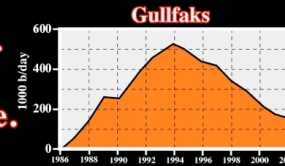


Suppose a bacteria doubling every 30 minutes. After one week all Solar System will be filled, and after 11 days all Universe will be filled.

Finiteness



All oil fields after reaching a peak production decline.



The rate of decline varies according to the volumes each field was producing when it peaked. Hydrocarbon output begins to decline as encroaching water and gas simply crowd out the oil (M. Simmons, 2005).

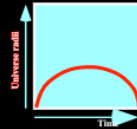
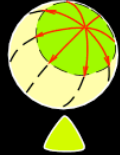
Finiteness

Three spaces are possible in relativity:

- 1) Nul curvature,
- 2) Positive curvature,
- 3) Negative curvature.

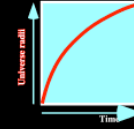
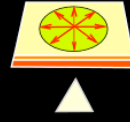
2) Positive curvature

Closed Universe



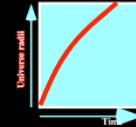
1) Nul curvature

Flat Universe



3) Negative curvature

Open Universe



The more likely, it is the one with a positive curvature (2).



*What means finiteness
in mathematical terms*

Suppose this natural distribution:
2, 4, 6, ?, ?, ?
rank: 1, 2, 3, n-2, n-1, n
value: 2, 4, 6, N-2, N-1, N



How many solutions do you propose?

There is a large number of solution:

There are 14 solutions

2, 4, 6, 8, 10, 12, 14, 16	$N=2n$ or $N=(N-1)+2$
2, 4, 6, 10, 16, 26, 42, 68	$N=(N-1)+(N-2)$
2, 4, 6, 8, 10, 12, 14, 16	$N=2(N-1)-(N-2)$
2, 4, 6, 6, 0, -18, -54, -108	$N=3(N-1)-3(N-2)$
2, 4, 6, 4, -14, -76, -234, -556	$N=4(N-1)-9(N-2)$

and so on

Occam's razor suggests the simplest,
i.e. minimum complexity

2, 4, 6, 8, 10, 12, 14, 16 $N=2n$

But



In Nature, too simple is often false

All that is simple is false and all that is complex is useless.
(Paul Valéry)

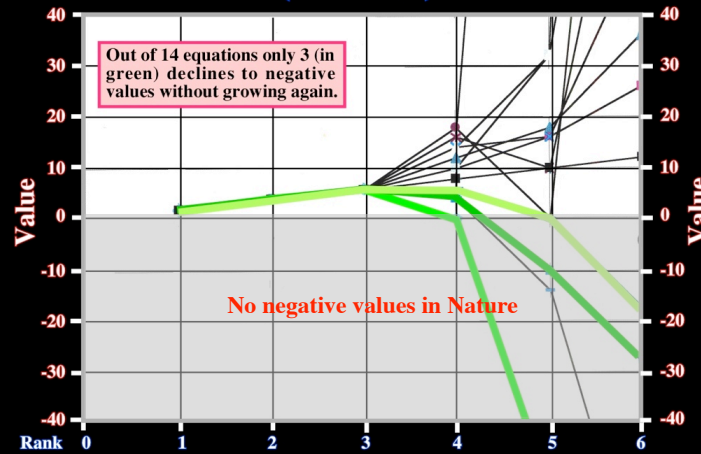
Continuous growth
is
impossible in Nature



Indeed, the series **2, 4, 6, ?, ?, ?**, has a beginning and grows, in life, it should peak and decline, negative values do not exist.

Continuous Growth is Impossible in Nature

2,4,6,?,?,?
(14 solutions)

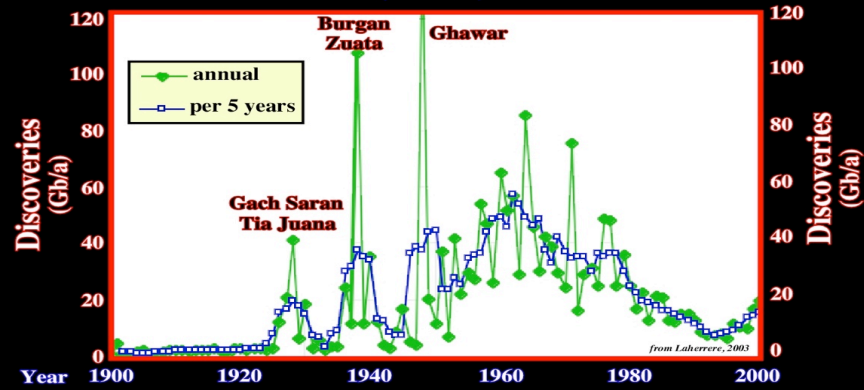


The simplest natural answer is 2,4,6,6,0 (N=3(N-1)-3 (N-2)). Notice that modelling is just an approximation (there are no negative values in Nature). It should be simple and convenient. Many models can fit the data, but some give unrealistic extrapolations. Try different models and check the extrapolations. Select the models that fit other natural distributions.

The simplest natural answer is
2, 4, 6, 6, 0 $N=3(N-1)-3(N-2)$

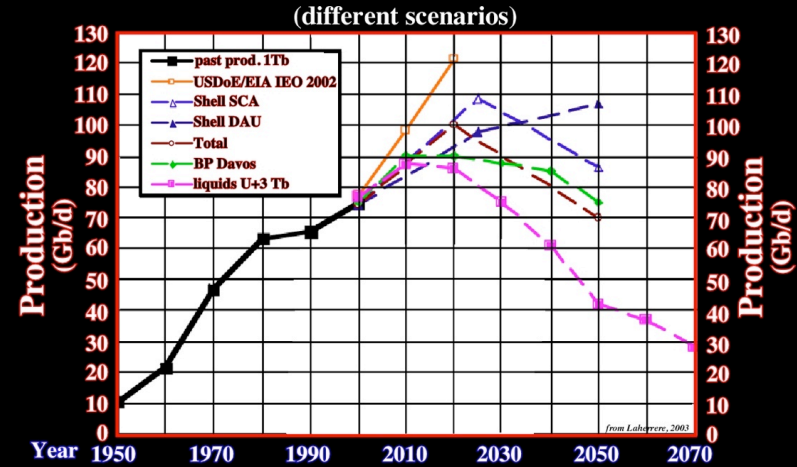
Therefore, the same happens with oil production,
 remaining reserves, oil discoveries, etc.

**Discoveries Oil+Condensate
 (World)**



Finiteness

World Oil Production

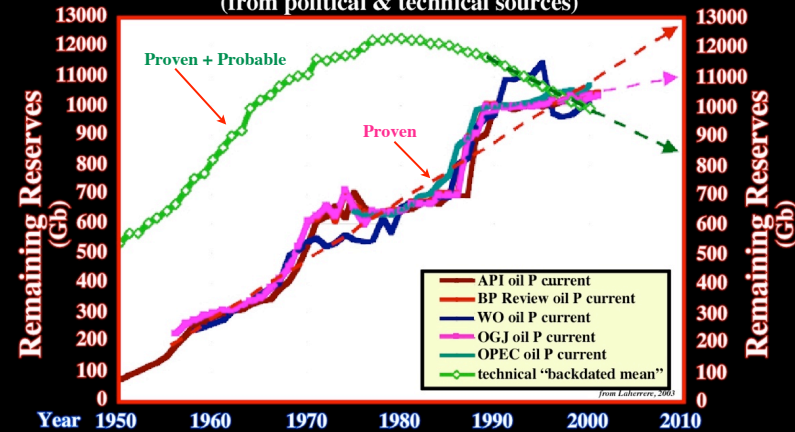


Assuming that when oil production peaks half of the reserves have already been produced, one can say that cheap oil is finished. Probably, very soon, if not already, we will be in left part of the purple curve. The discrepancies between the curves are artificial; lot of them are based in political and not technical data.

Finiteness

World: Oil remaining Reserves

(from political & technical sources)



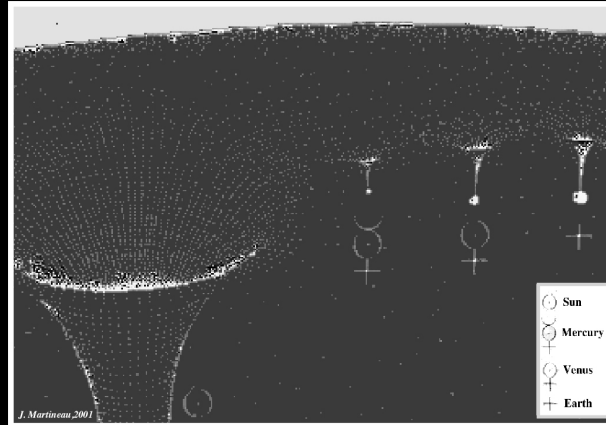
Those acquainted with oil business know reserves can change according to economical and political interests. On this plot, the green curve, made up with technical data (proven + probable, corrected), strongly indicates that since 1980, the oil produced is not replaced by discoveries. This obvious fact does not interest several oil companies and government, which assume an eternal growth (proven) (*"nihil aliud opus est"*). USA companies follow the Securities and Exchange Commission which, contrarily to all other countries, publishes only proved reserves (financial data) and not probable reserves (technical data).

Gravitation

Everything is curved.
Linearity exists only locally



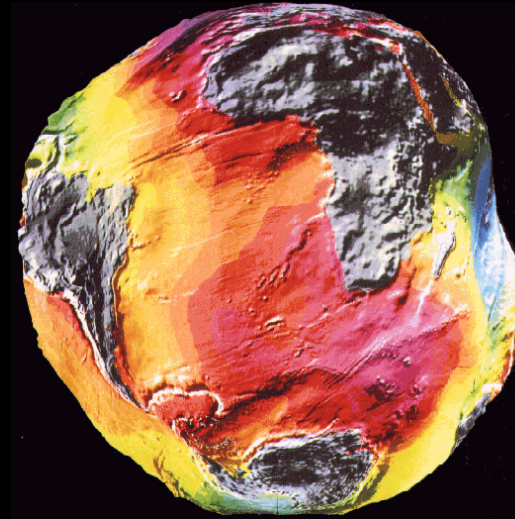
To picture the solar system think of space-time as a rubber sheet with the Sun as a heavy ball and planets as a marble place on it. This is Einstein's model of the way matter curves space-time and helps visualise the force of gravity between masses.



Gravitation

Gravity Anomalies

The geoid is the most graphical representation of the Earth gravity field. The largest positive geoid heights are associated with subduction zones and hotspots and have no simple relationship to other high regions such as continents and ridges. Subsequently, as sea level is not uniform, a global rise of 10 meters, induced for instance by a deglaciation, does not give the same relative consequences all around the Earth. Probably, in sequence stratigraphy, the majority of unconformities have a regional extend but not global.



Earth's Morphology

All clastic sediments are deposit by gravity



Yes, I see

Braided-streams



Eolian deposits



Pyroclastis deposits

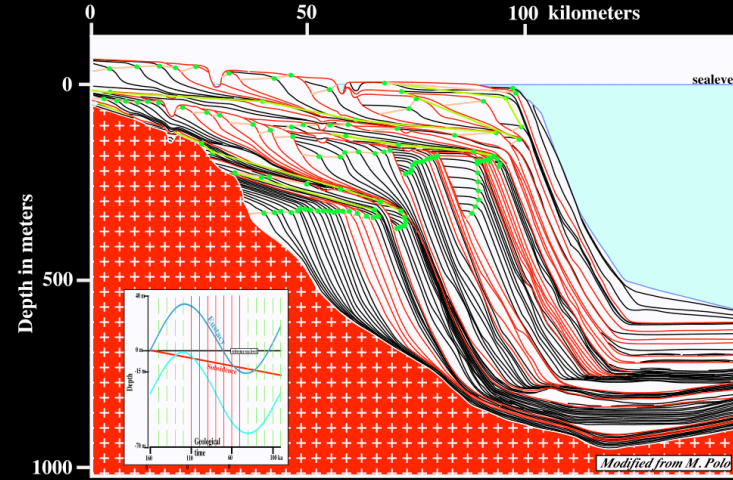


Snow deposits



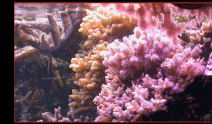
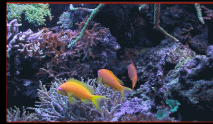
Marine Clastic Deposition

(after P. Vail, 1977)



Eustasy is supposed to be the major reason of the cyclicity of the sediments. However, sediments must be transported before being deposited, so gravity plays also an important role. In this model, the vertical exaggeration is almost 100 x. Each black line corresponds to a chronostratigraphic line. Their spacing is 100k years. Terrigenous influx is constant (area between two consecutive chronostratigraphic lines is the same). The red lines correspond to unconformities (erosional surfaces). The green dots underline the successive positions of the shelf breaks.

Life

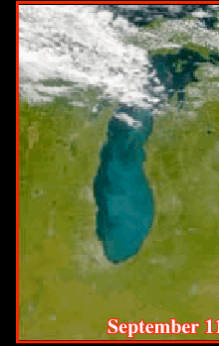
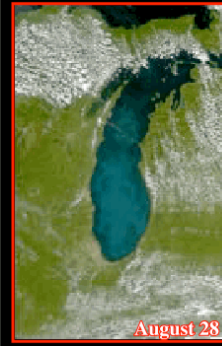
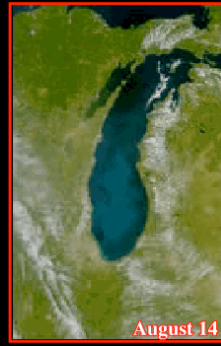


Life is everywhere



Life

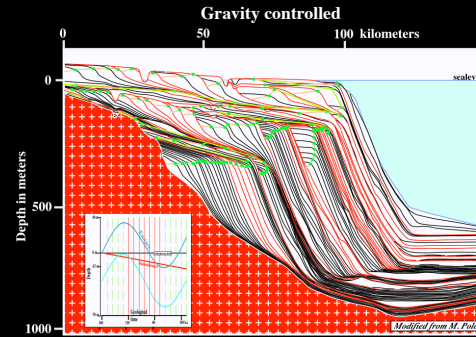
Lake Michigan



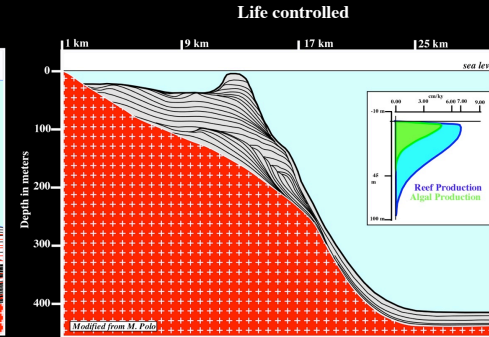
The bright color that appears in late summer in Lake Michigan is caused by the calcium carbonate in the water and not by life. Lake Michigan always has a lot of calcium carbonate because the floor of the lake is limestone. During most of the year the calcium carbonate remains dissolved in the cold water, but at the end of summer the lake warms up, lowering the solubility of calcium carbonate.

Life & Gravity control sedimentation

Vail's model for clastics

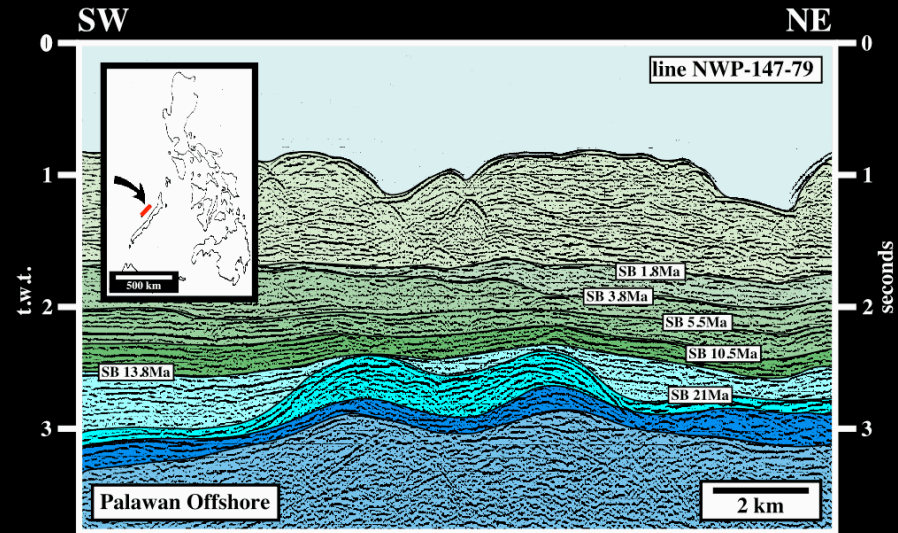


Vail's model for carbonate



The carbonate depositional model of Exxon is illustrated on right was built using Marco Polo software. The parameters Eustasy and Subsidence are exactly the same that those used in the sand-shale model, also, the relative sea level curve is the same in both models. The only difference is the sedimentary input. In the sand-shale model, the sediments are transported from the continent toward the sea and the terrigenous input is conventionally taken as constant, in the carbonate model, the algal and reef production are maximal (5-7 cm/ky) near surface at 2-3 meters water depth.

Carbonate Buildsups



Carbonate buildsups, as those illustrated on this line from off as other organic rocks obey to the three basic principles controlling life that we will review next.

Life

**Life is controlled
by three major
laws**



Which laws?

Life is controlled by three major laws



- a) **Fermat-Maupertius's law**
or Principle of minimum action.
- b) **Snell's law**
or Principle of minimum time.
- c) **Fibonacci's law**
or Principle of maximum room.

Fermat-Maupertius's law

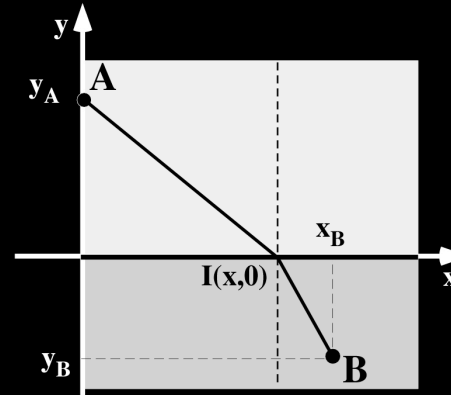
(Principle of Minimum Action)

“Entia non sun multiplicanda praeter necessitatem”

William Ockham (1290-1349)

Entities should not be multiplied unnecessarily

Pierre de Fermat (1601-1665) postulated the luminous rays followed a general principle according which the path borrowed by light to go from a given point to another was that for which the time of course was a minimum. En 1744, P. de Maupertius put forward that physical events followed a basic principle: “Nature follows always, among all possibilities, the more efficient one”. In the case of movement, for instance, such efficiency is corresponds to the minimum velocity for the minimum of traversed path. (Principle of minimum action).

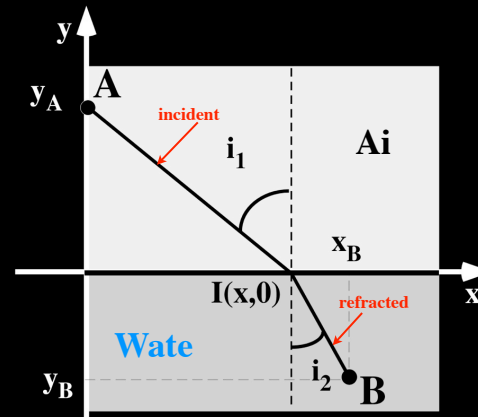


Snell's law

(Principle of Minimum Time)

During refraction of light, the ratio of the sines of the angles of incidence (i_1) and refraction (i_2) is a constant equal to the refractive index of the medium.

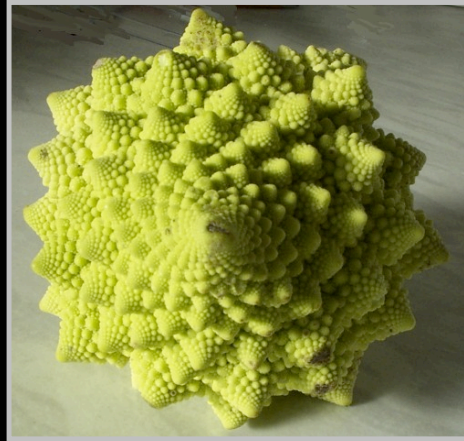
The reflection case illustrates a point about Fermat's principle: the minimum time may actually be a local rather than a global minimum. Trajectories allowed by Fermat's principle don't strictly have to be minimum time trajectories. They can also be maximum time trajectories.



Fibonacci's law

(Principle of Maximum Room)

In a Fibonacci sequence each term (after the first two) is the sum of the preceding two: 1, 1, 2, 3, 5, 8, 13, 21, 34, 55...



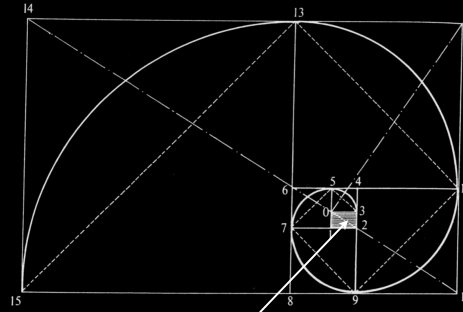
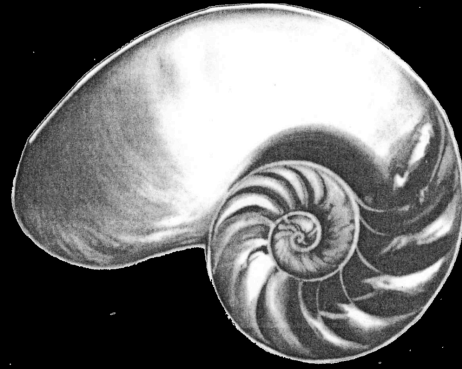
Each floret is peaked and is an identical but smaller version of the whole thing and this makes the spirals easy to see.

This simple pattern can determine the shape of a seashell, pine-cones or the sprouting of leaves from the stem of any plant. This connection to the organic world is reflected in the surface pattern, which is achieved through the process of smoke firing.

Fibonacci sequence has many other interesting mathematical properties. For example, the ratio of successive terms (larger to smaller; $1/1, 2/1, 3/2, 5/3, 8/5, 13/8...$) approaches the number 1.618 (phi). This ratio is known as the Golden Ratio.

Fibonacci's law

(Principle of Maximum Room)



"The eye of God"

T. Ferris, 1992

The architecture of Nautilus' shell can be compared with a series of nested Golden Rectangles obtained when you snip off squares from a Golden Rectangle. If we connect the successive points where these whirling squares divide the sides in Golden Ratios, we obtain a logarithmic spiral that coils inward toward the pole (the point given by the intersection of the diagonals, which was called fancifully "The eye of God").



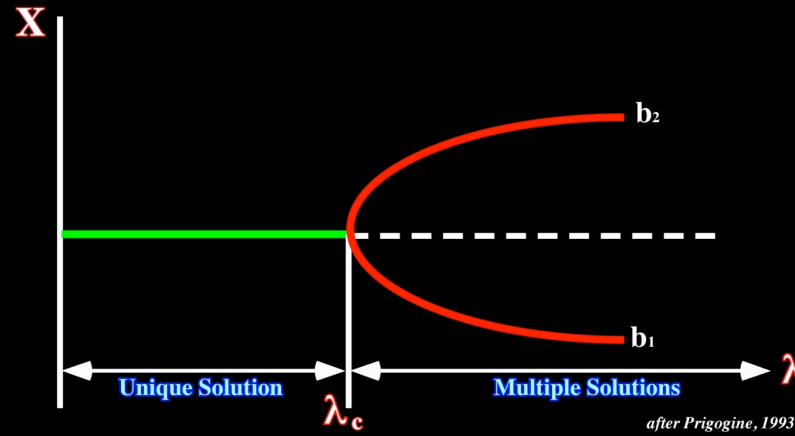
Natural evolution is a succession of stages described by determinist laws and stages described by probabilistic laws.



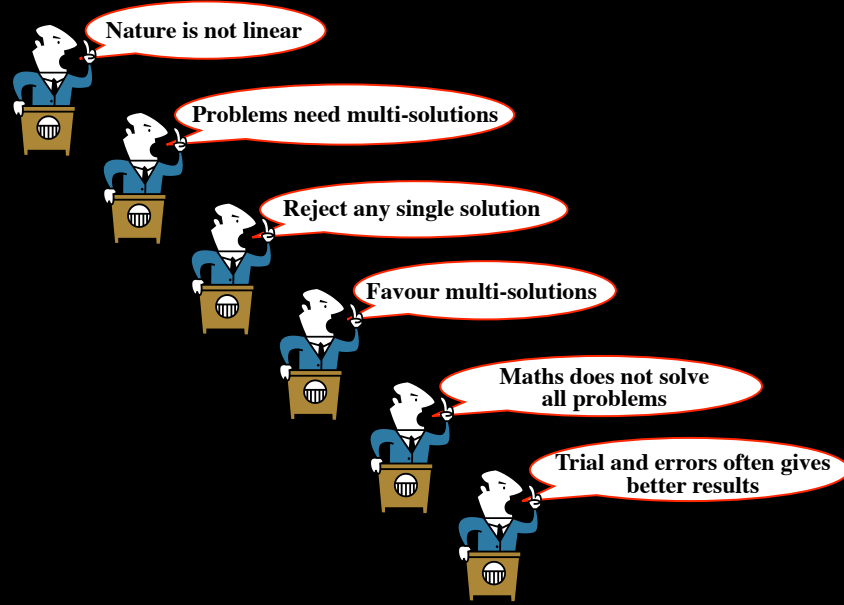
Small causes
Big effects



Bifurcation Points



Concentration X is a function of the parameter λ , which measures the distance from equilibrium. At the bifurcation point, the thermodynamic branch becomes unstable, and two new solutions b_1 and b_2 emerge. Beyond the bifurcation point, a set of new phenomena arise. Prigogine named these spatio-temporal organizations: Dissipative Structures. Irreversible processes describe fundamental features of Nature leading to nonequilibrium dissipative structures. For unstable systems we have to formulate the laws of dynamics at the statistical level. In such a formulation, the basic objects of physics are no longer trajectories or wave functions. They are probabilities. (Prigogine, 1993).



Finally

**Do not hide errors
but
try to not repeat them**

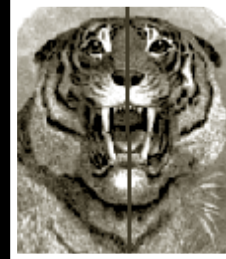
**Symmetry is a
major characteristic
of Nature**



One speaks of symmetry when a quantity
remain unchanged during a transformation

Symmetry

A shape has line symmetry when one half of it is the mirror image of the other half.



Symmetry exists all around us and many people see it as being a thing of beauty.

Symmetry

Symmetry exists also in music. An example particularly clear is given by the composition, probably apocryphal, of a piece of music in two parts (Mozart ?), which starts by:



and ends by:



The end is a image in a mirror of the beginning.

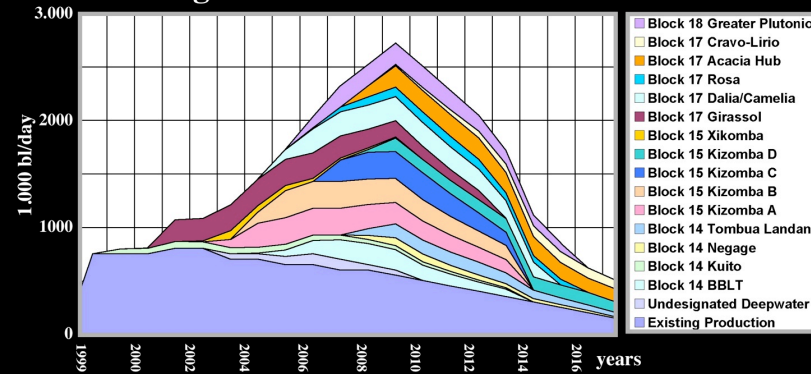
Such a piece should be numbered Koehel 609, but Alfred Einstein put it in the *Anhang*, or appendix, of the doubtful pieces: Anh 284dd (P. Atkins, 2003).

Central Limit Theorem

(Large numbers)

In probabilities, adding a large number of asymmetric distributions gives a symmetrical normal distribution.

Angola Production Fields



Individually the production curve of each field is asymmetric. However, when taken collectively the curve shows a quite sharp symmetry.



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