HC Problems & Nature Principles

Carlos Cramez & Jean Laherrere

C. Cramez, Switzerland
ccramez@compuserve.com

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.

C. Cramez, Switzerland
ccramez@compuserve.com

ASPO France

Part I

HC Problems Review

C. Cramez, Switzerland
ccramez@compuserve.com

HC Problems

1) At the end 2005, the amount of liquid hydrocarbons produced since 1859 is (±1-2%) 1 000 Gb (1 000 billion barrels).

2) Likely, the remaining reserves are:

- 1 000 Gb of oil,
- 500 Gb of extra-heavy,
- 250 Gb of natural gas liquids,
- 250 Gb of refining technology

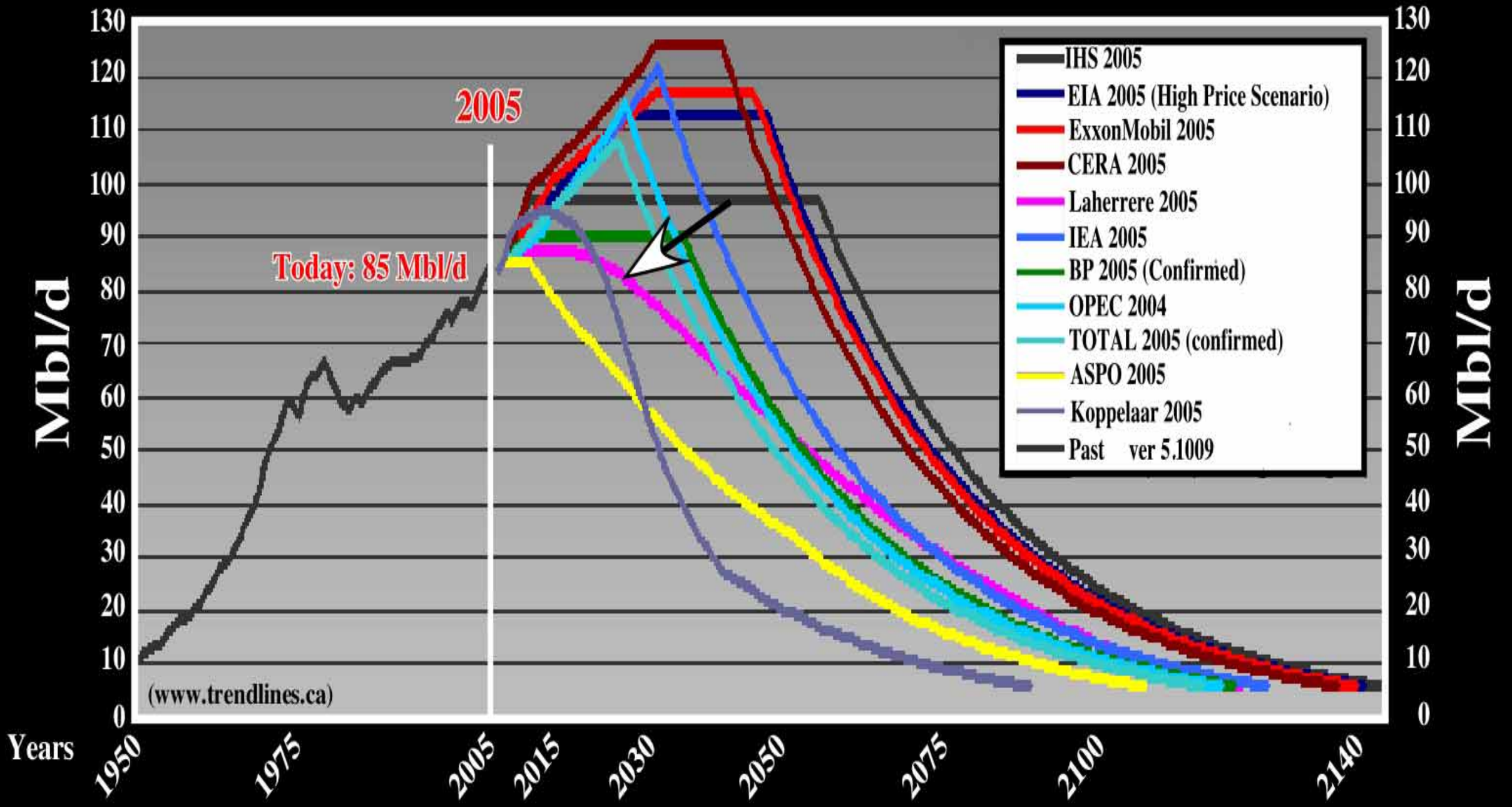
+

synthetic oils from coal & biomass.

C. Cramez, Switzerland
ccramez@compuserve.com

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, PB, Total, OPEC, etc.

C. Cramez, Switzerland
ccramez@compuserve.com

HC Problems

3) In early 2005, estimated global oil demand was forecast to reach 86 Mb/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.

C. Cramez, Switzerland
ccramez@compuserve.com

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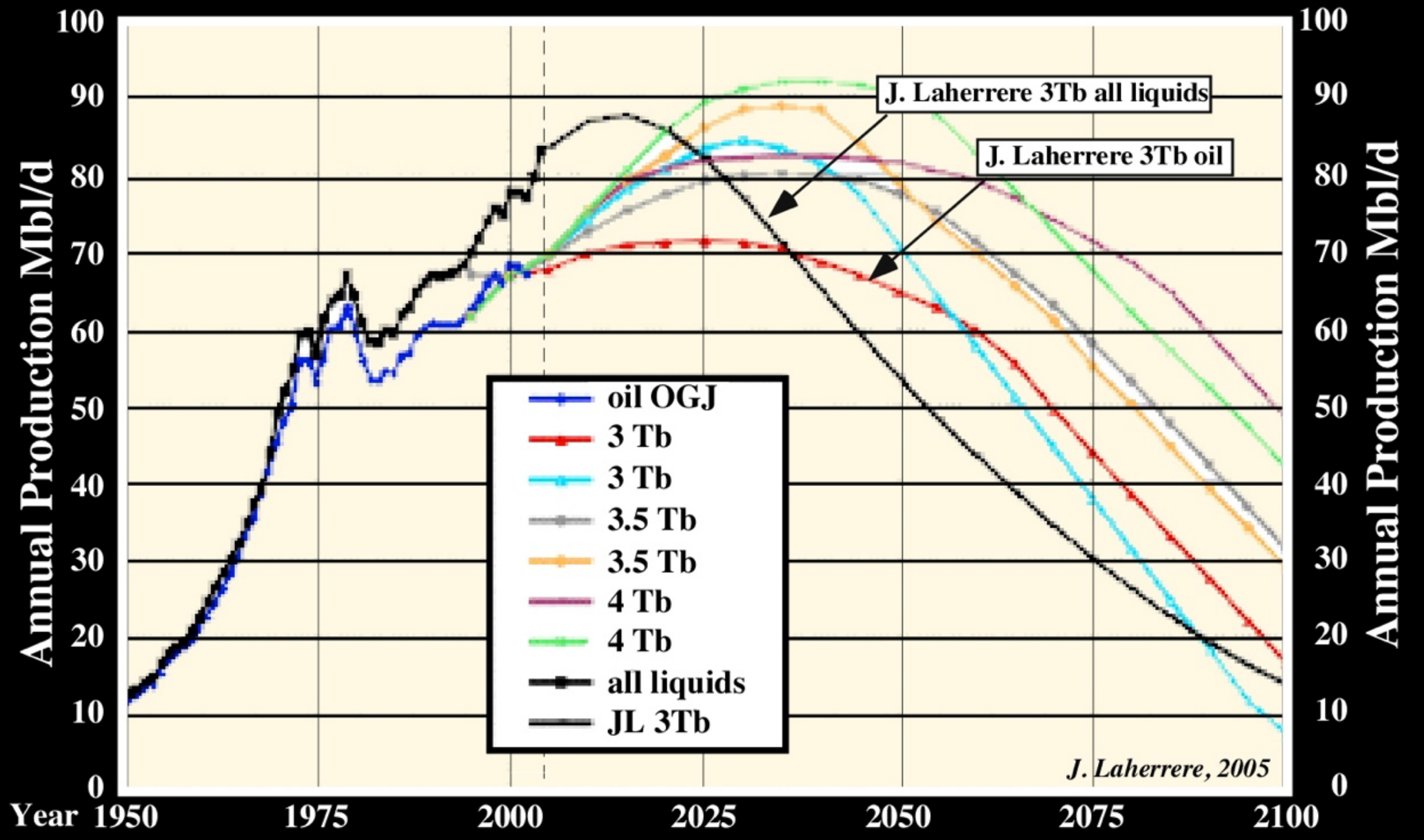
Oil Production Forecast

(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 Gb) of ultime reserves.

C. Cramez, Switzerland
ccramez@compuserve.com

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 (Kasaghstan, Gulf of Mexico, West Africa), but none of these projects is expected to produce in excess of 200-250 kb/d.

C. Cramez, Switzerland
ccramez@compuserve.com

HC Problems

7) The volume of water produced from the world's oil fields is now estimated to exceed 200 Mb/d, nearly 3x the volume of the oil. Oil wells in US produce more than 7 bl 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. 1 000 x more expensive than oil + engine.

C. Cramez, Switzerland
ccramez@compuserve.com

(J. Laherrere, 2006)

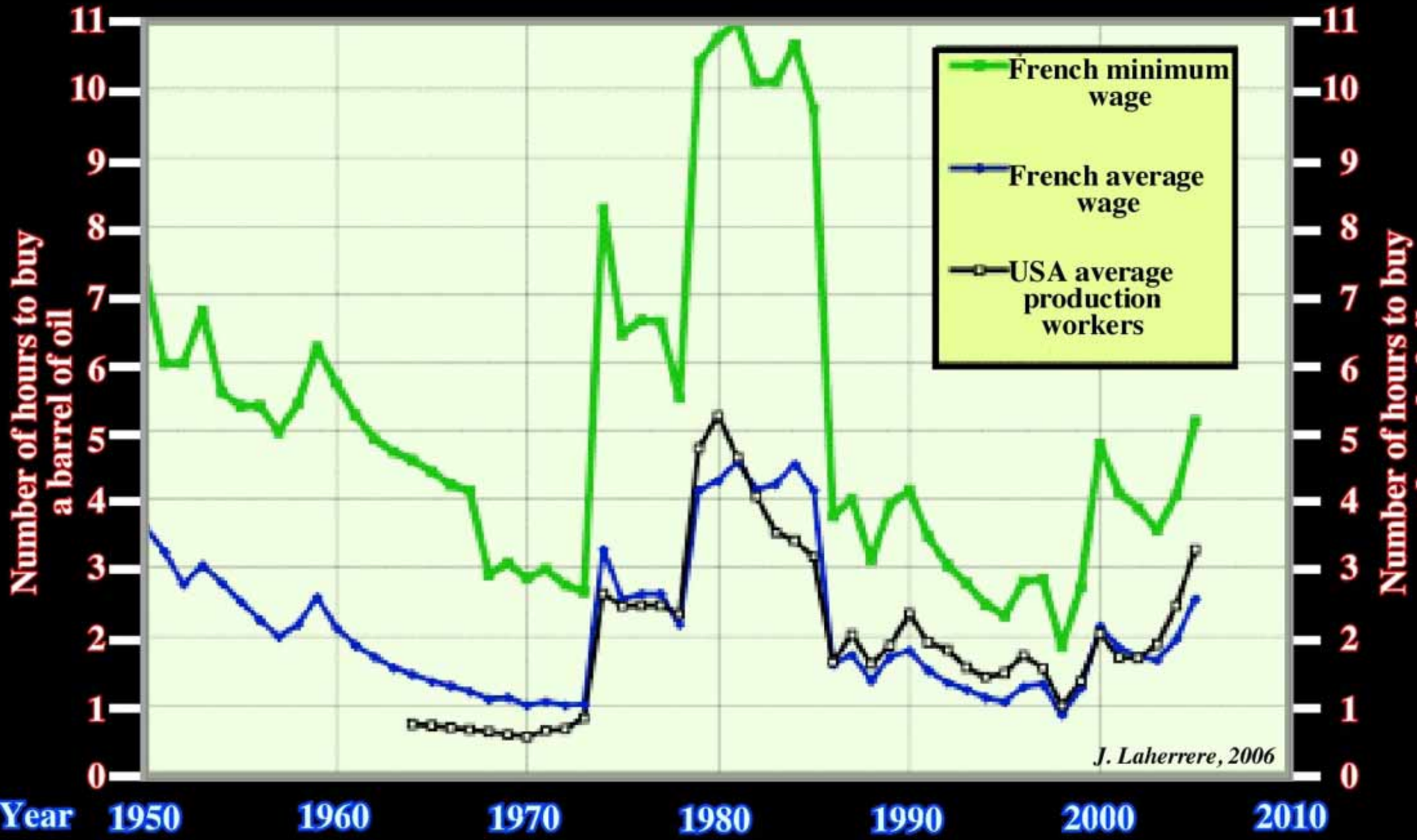
- **By the end of 2005, an European worker (minimum wage) should work 4-5 hours to buy a barrel of oil, while an American worker should just work 2-3 hours to buy it .**

- **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).**

C. Cramez, Switzerland
ccramez@compuserve.com

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.

C. Cramez, Switzerland
ccramez@compuserve.com

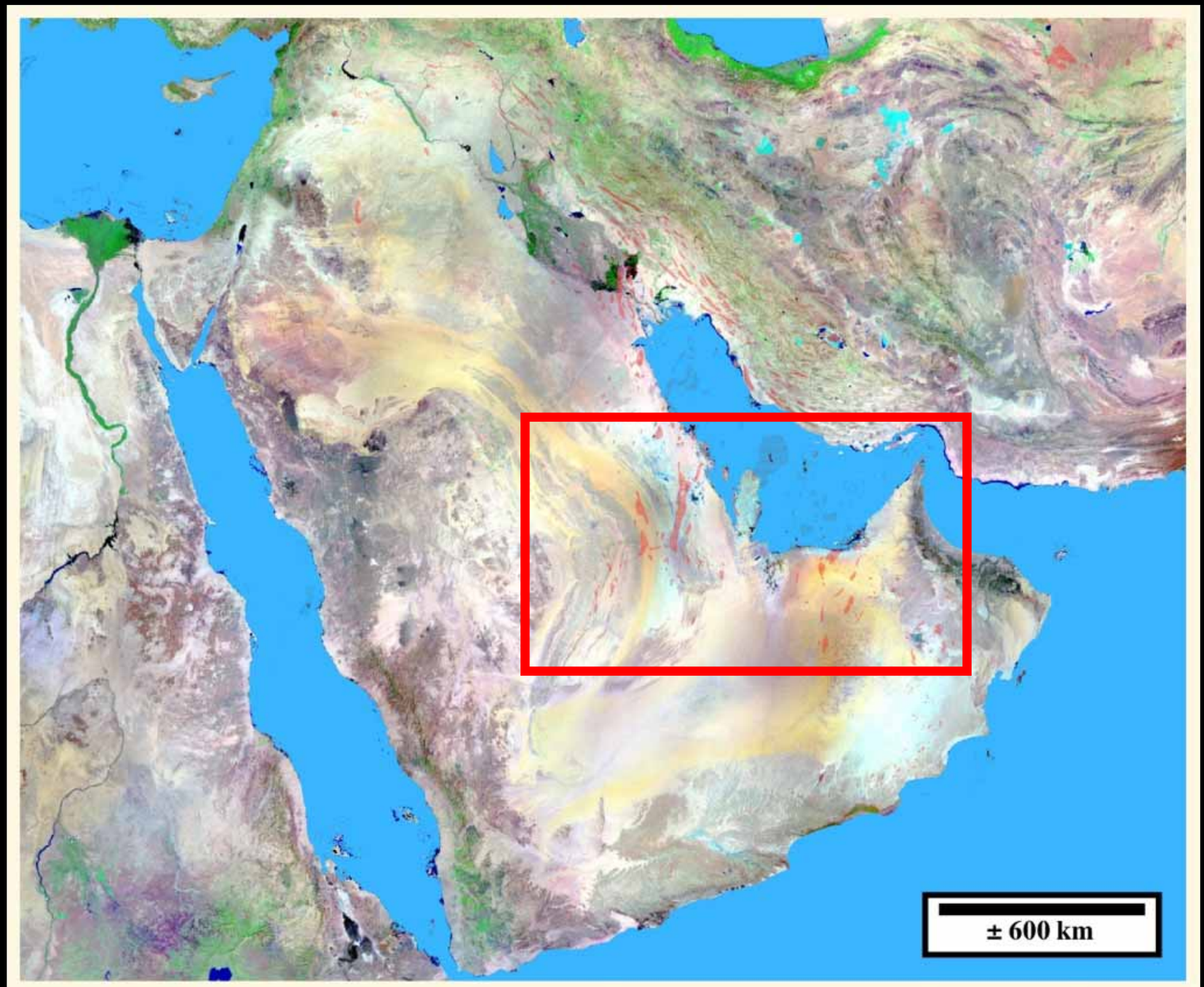
(M. Simmons, 2005)

- **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 Mb /d.**

C. Cramez, Switzerland
ccramez@compuserve.com

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.

C. Cramez, Switzerland
ccramez@compuserve.com

Saudi Arabia Oil Fields Dynasty

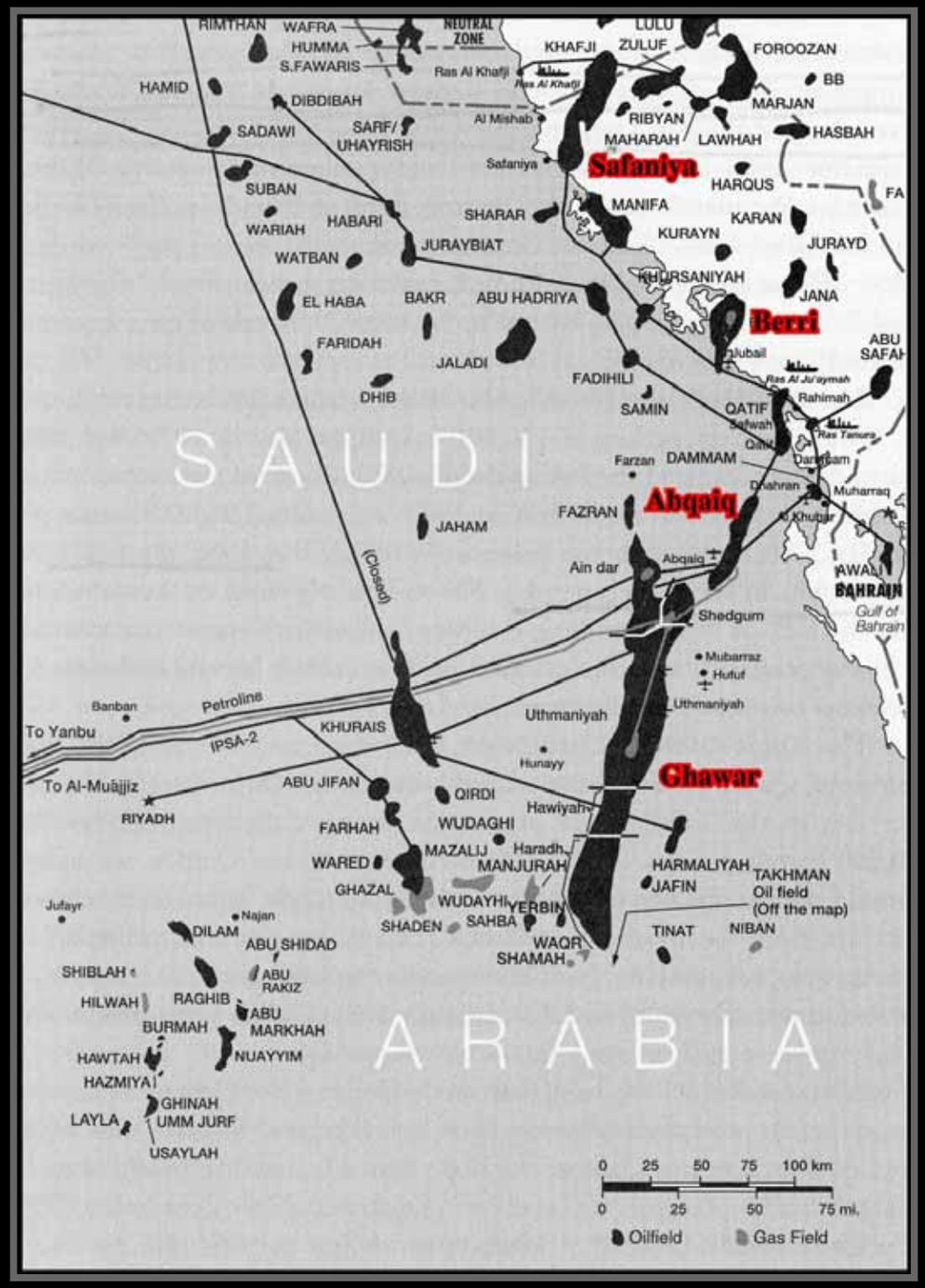
Saudi Arabia represents roughly 40% of Middle East reserves. They are mainly associated with four major fields:

(i) the "King" Ghawar,

(ii) the "Queen" Safaniya,

(iii) the "Dowager Queen" Abqaiq and

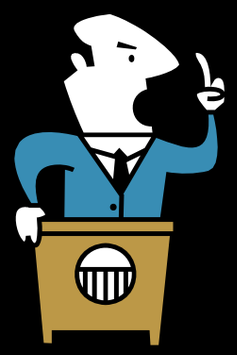
(iv) the "Prince" Berri.



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.

C. Cramez, Switzerland
ccramez@compuserve.com

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



C. Cramez, Switzerland
ccramez@compuserve.com

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:

C. Cramez, Switzerland
ccramez@compuserve.com

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.

C. Cramez, Switzerland
ccramez@compuserve.com

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** (Problem, Hypothesis, Test)

C. Cramez, Switzerland
ccramez@compuserve.com

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.

C. Cramez, Switzerland
ccramez@compuserve.com

The Oil Pyramid

Average Field Production (barrels /day)	Total Contribution of Fields (000 bpd) (% of World total)	Number of Fields	Field Output (barrels per day)
993,000	13,900 (20%)	14	500,000
342,000	4,100 (6%)	12	300,000
221,000	6,400 (9%)	29	200,000
130,000	7,900 (12%)	61	100,000
9,000	36,200 (53%)	4,000 +	0

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.

C. Cramez, Switzerland
ccramez@compuserve.com

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 word 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 diary 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 Altantic Margins were few fields with a potential of 200 000 / 300 000 barrels per day have been found, the picture stays the same.

C. Cramez, Switzerland
ccramez@compuserve.com

ASPO France

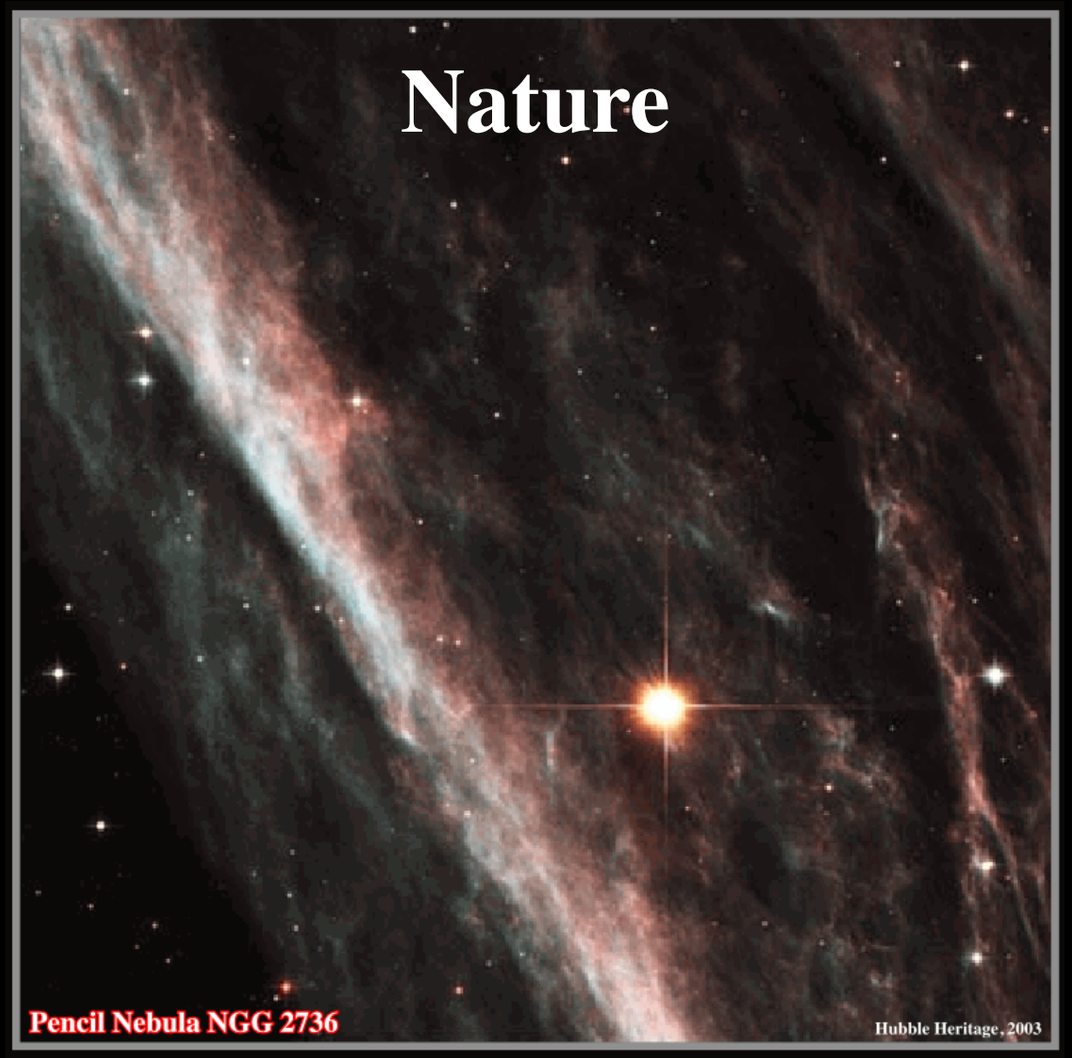
Part II

Nature Principles Review

C. Cramez, Switzerland
ccramez@compuserve.com

Nature is ruled by some basic Principles

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



C. Cramez, Switzerland
ccramez@compuserve.com

Inequality

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

C. Cramez, Switzerland
ccramez@compuserve.com

Inequality is the rule in Nature

C. Cramez, Switzerland
ccramez@compuserve.com

Inequality

Comsumption of Primary Energy

(CPE)

Region	CEP Gtep	Population G	CEP/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

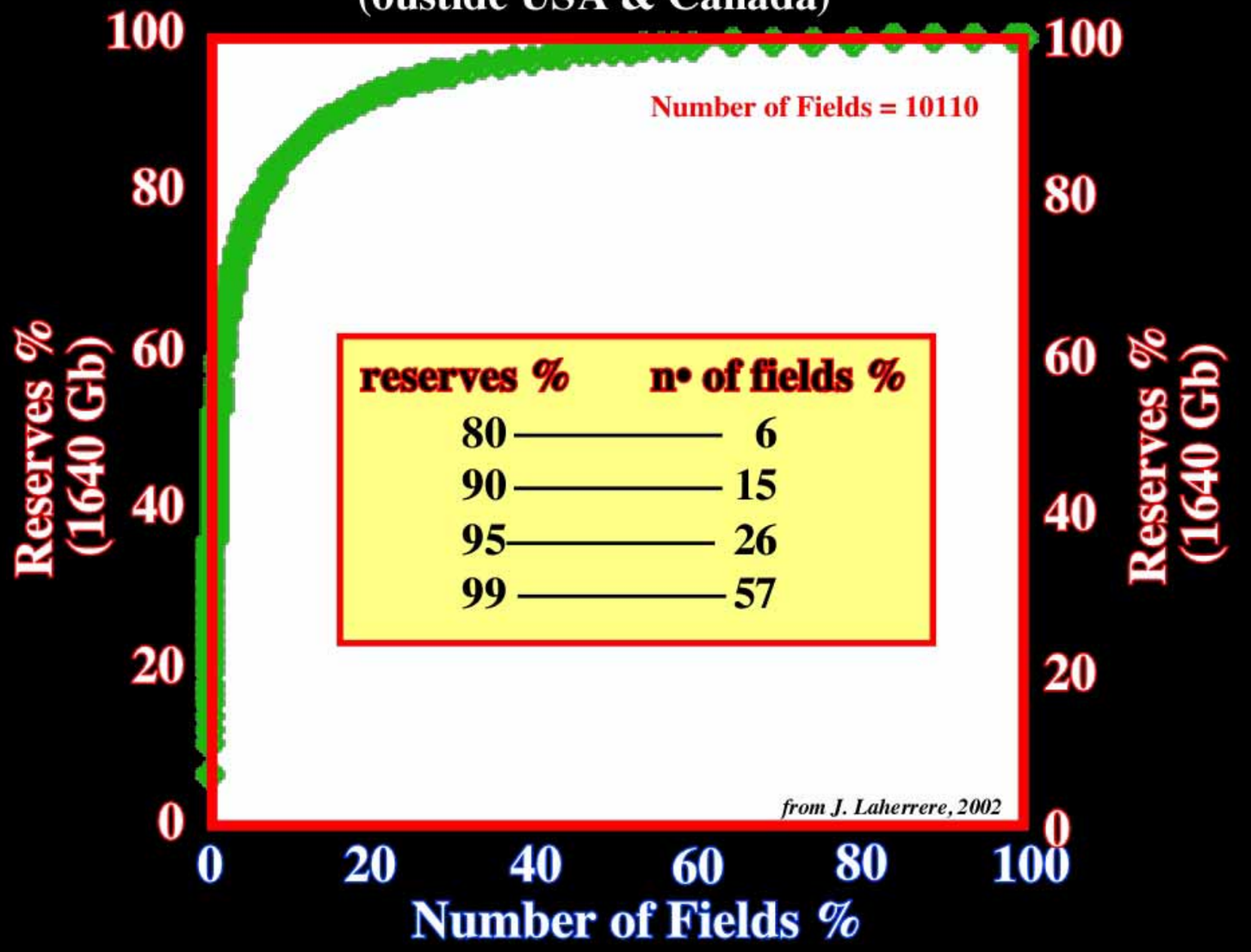
Rapport 2000 du Conseil Mondial de l'Énergie

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.

C. Cramez, Switzerland
ccramez@compuserve.com

Inequality

Reserves & Number of Fields



The worldwide oil field hierarchy is easily recognised on this plot. Ghawar, the King of 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.

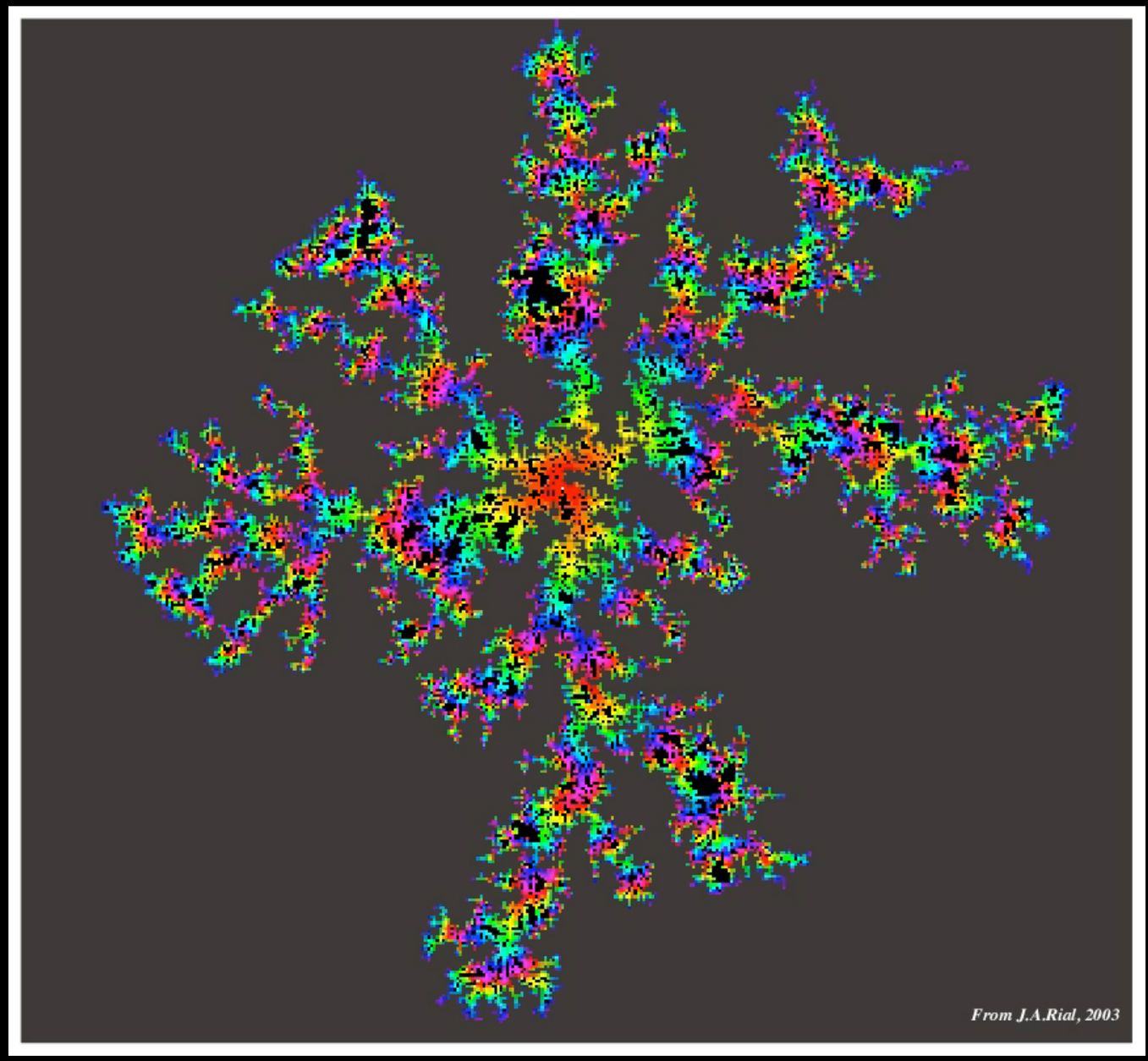
C. Cramez, Switzerland
ccramez@compuserve.com

Self-similarity

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

C. Cramez, Switzerland
ccramez@compuserve.com

A part is similar to the whole

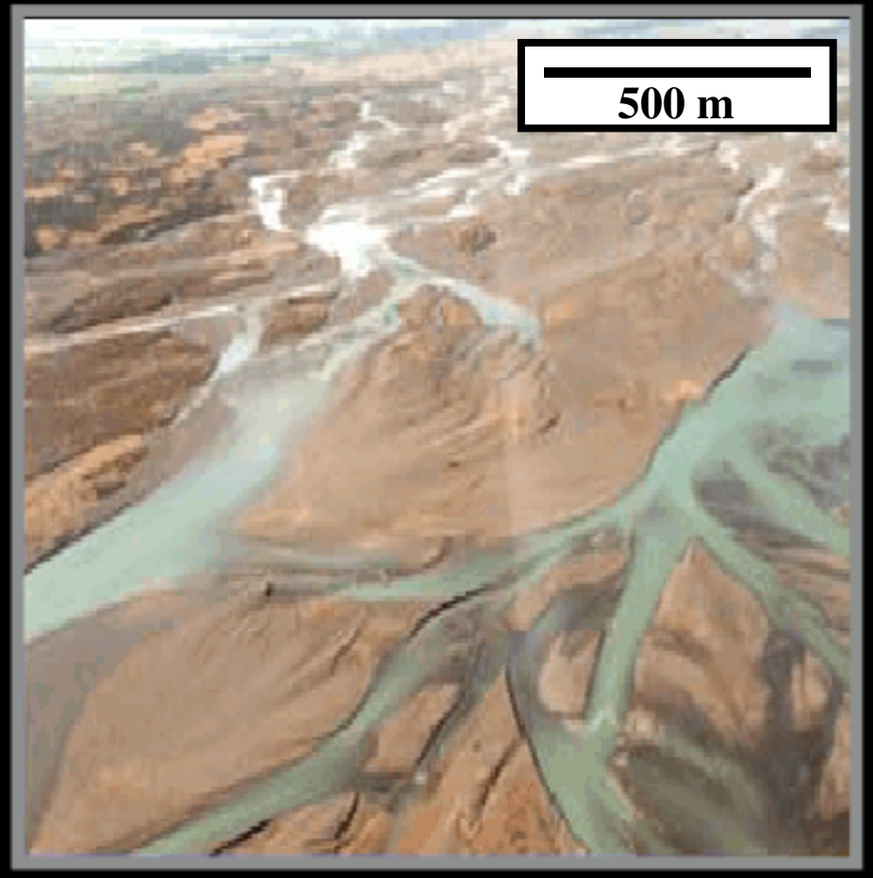


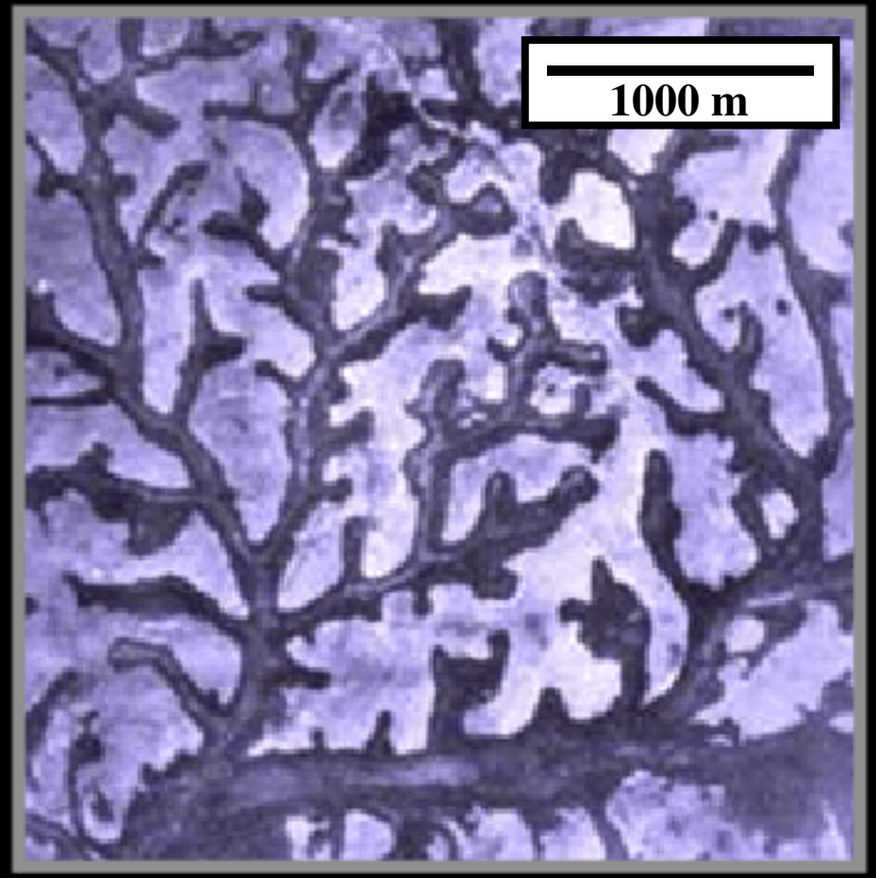
Simulation of crystal growth. The fine structure of the "crystal" is self-similar. A part is similar to the whole. However, it is relevant here to point out that the sum of the part is not equal to the whole. The whole is more than the sum of the parts and its characteristics cannot be approached by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

C. Cramez, Switzerland
ccramez@compuserve.com

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

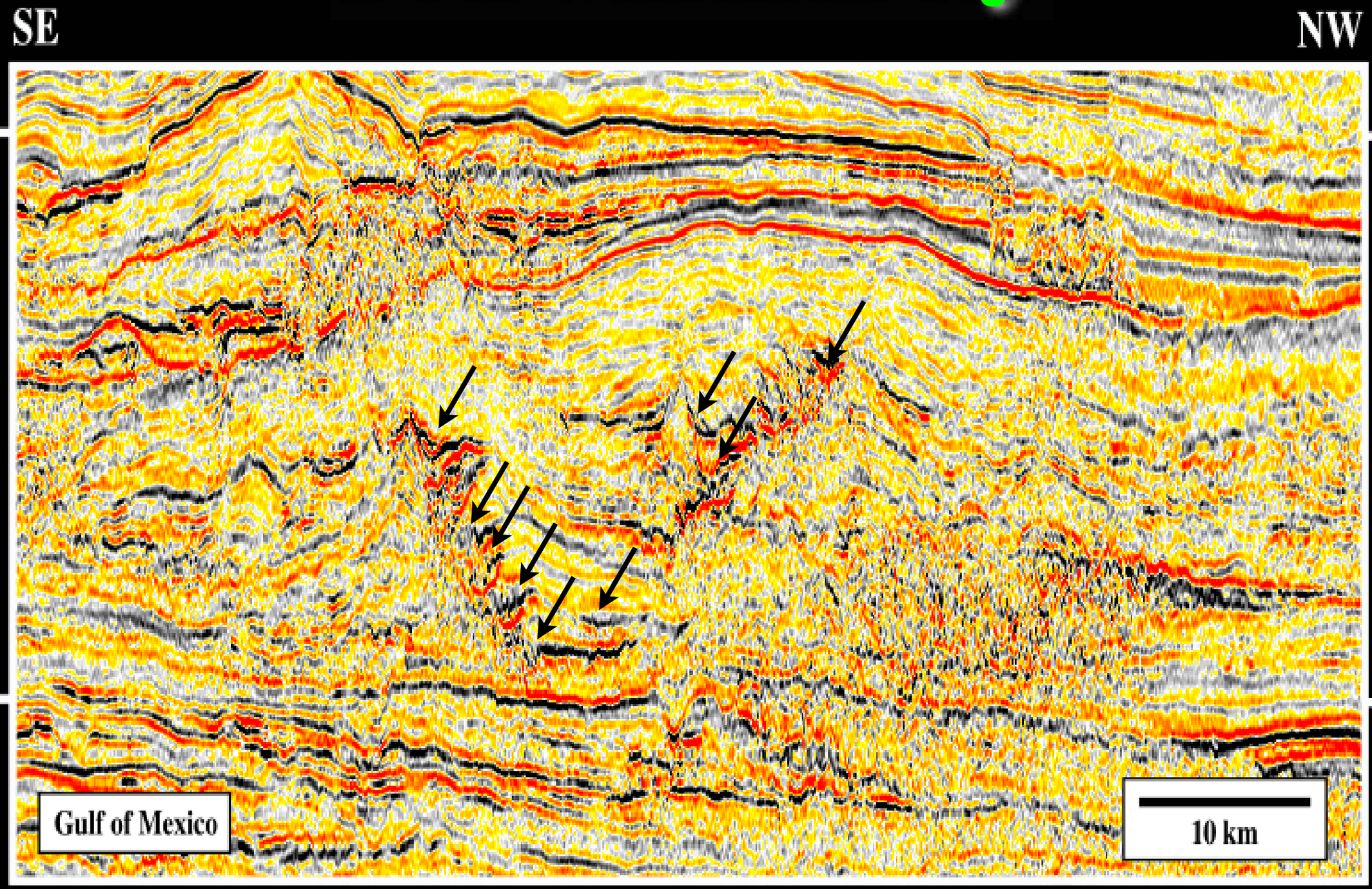
- Its parts have the same shape (structure), in spite of their scale or deformation.
- Its shape is either irregular, interrupted or fragmented independently the scale of observation.
- It contains distinctive elements, which scales are very varied and covering a very wide range.





C. Cramez, Switzerland
ccramez@compuserve.com

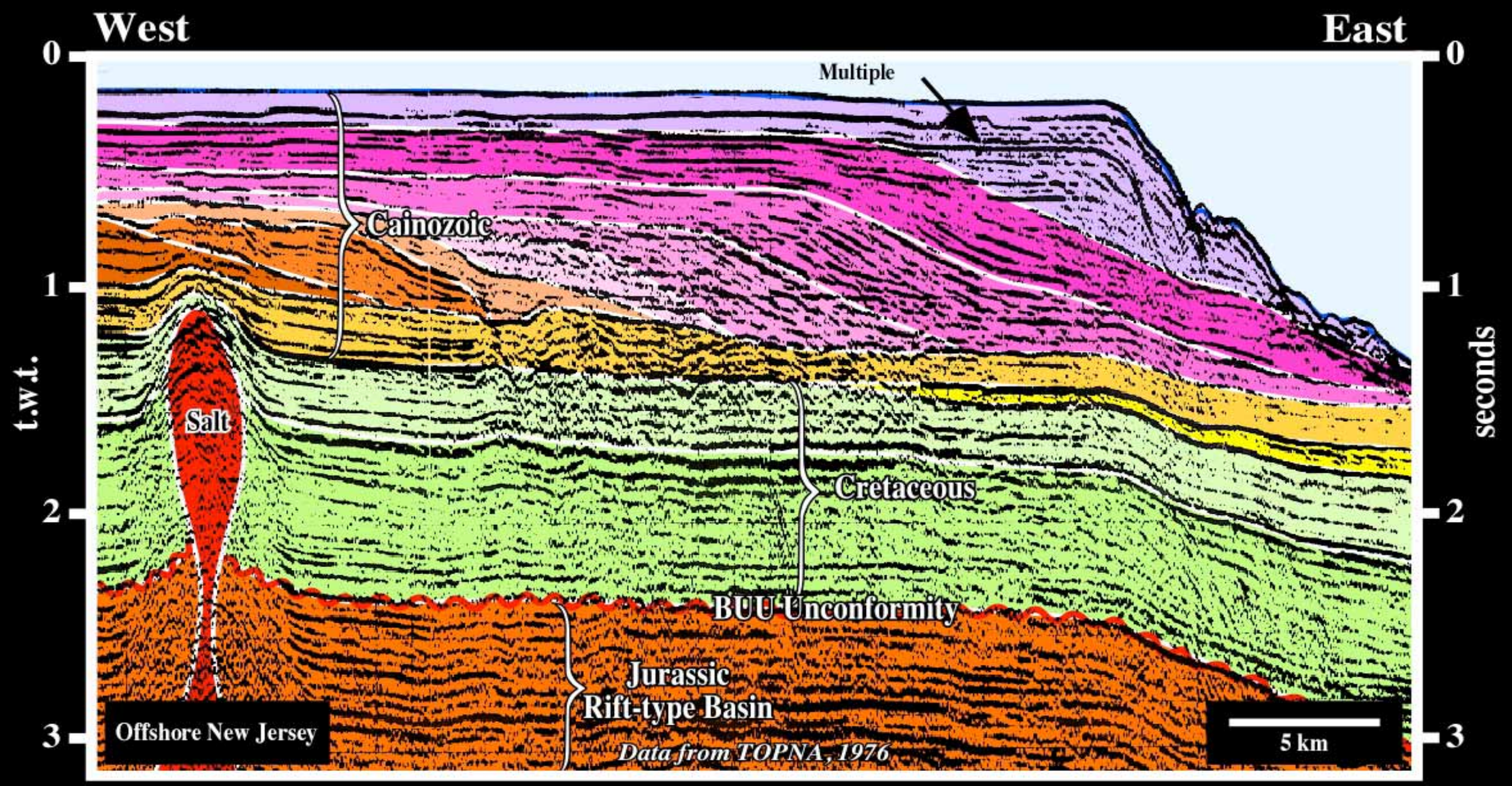
Self-similarity



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.

C. Cramez, Switzerland
ccramez@compuserve.com

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



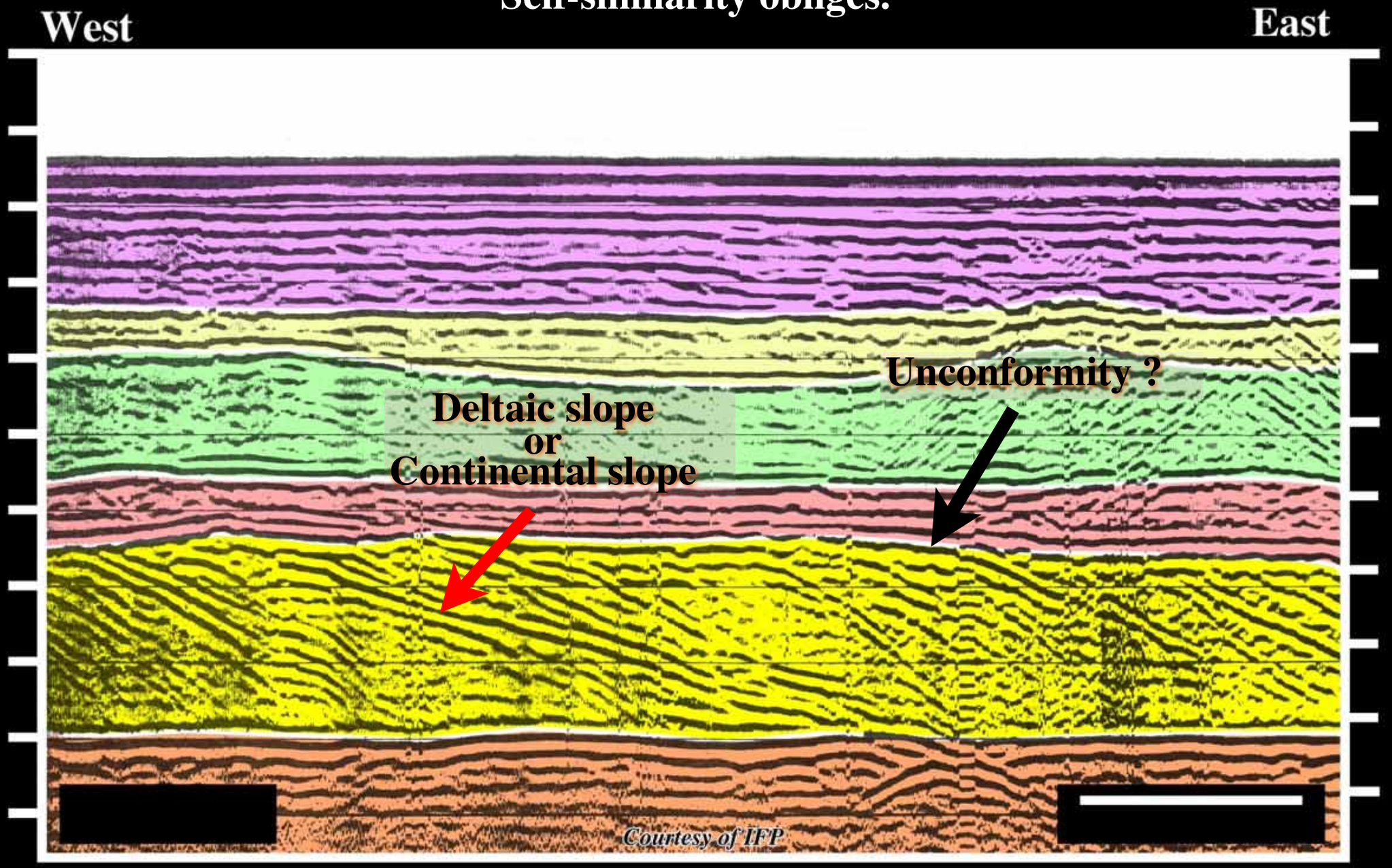
Without scales, orientation and location (outside of the geological setting) and the geological interpretation of a seismic line is meaningless, because self-similarity. Indeed, a slope delta is similar to a continental slope and to any offlap.

Self-similarity = Fractal

C. Cramez, Switzerland
ccramez@compuserve.com

Geology is Scale Dependent.

Interpretation requires a scale.
Self-similarity obliges.

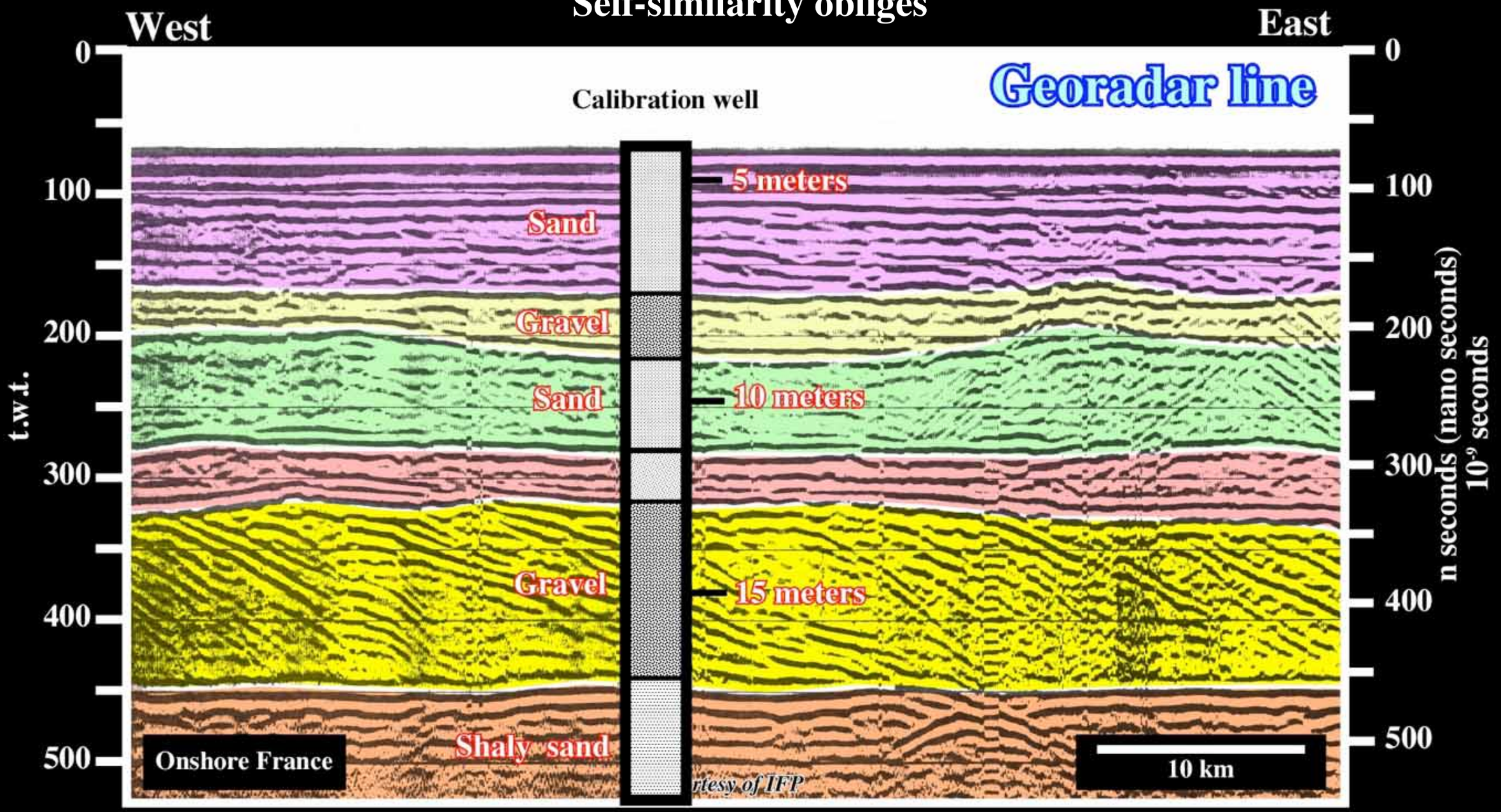


As Geology is scale dependent, geological seismic interpretations cannot be performed without knowing the scales, as well as the global and regional settings. On this line, interpreters will be enable to interpret the depositional inclined reflector . The reader is supposed to make a guess: shelf or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

C. Cramez, Switzerland
ccramez@compuserve.com

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).

C. Cramez, Switzerland
ccramez@compuserve.com

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.

C. Cramez, Switzerland
ccramez@compuserve.com

Fractal Distribution

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

have a fractal parabolic distribution.

C. Cramez, Switzerland
ccramez@compuserve.com

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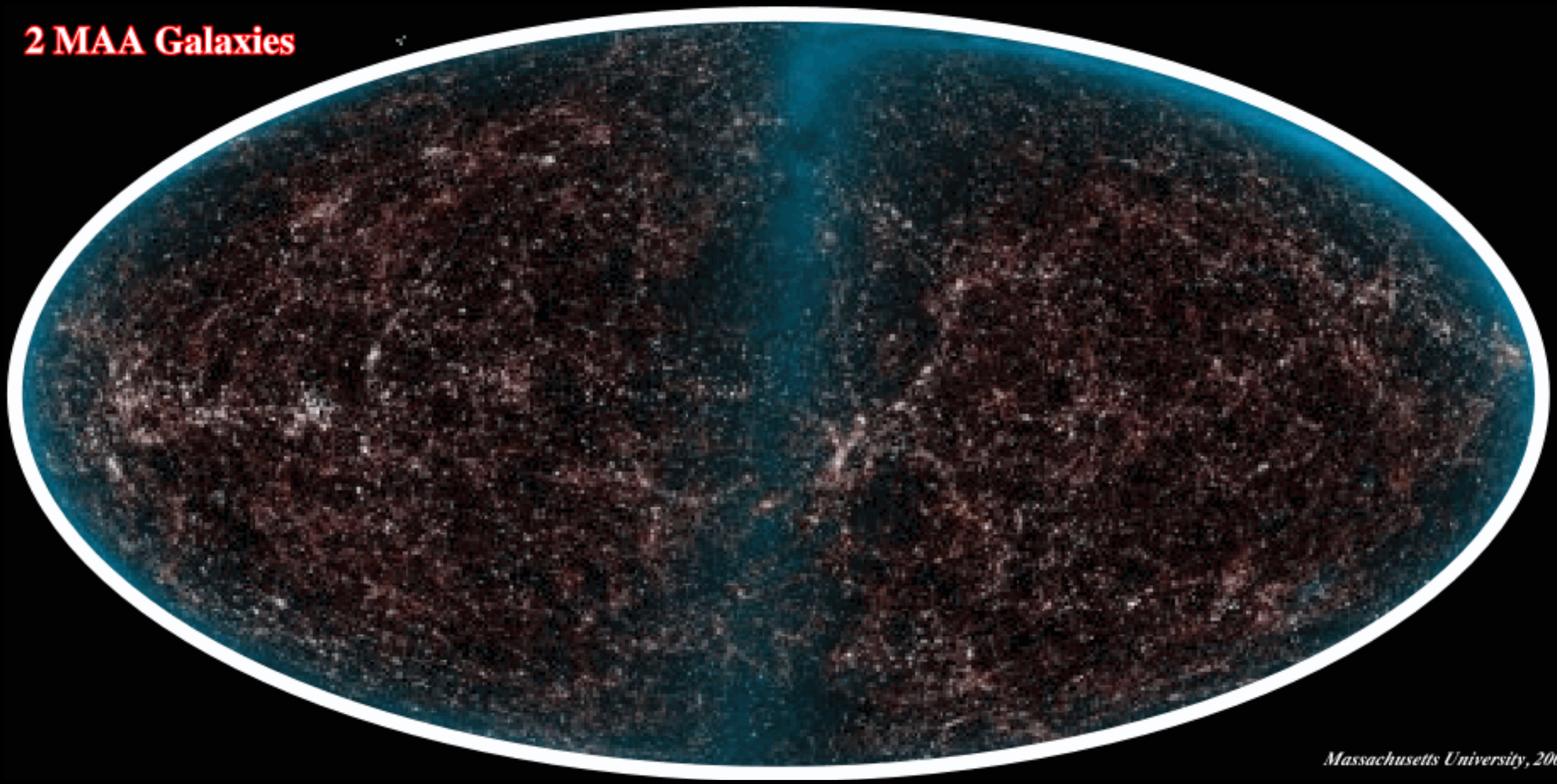
Galactic Intensity

2 MAA Galaxies



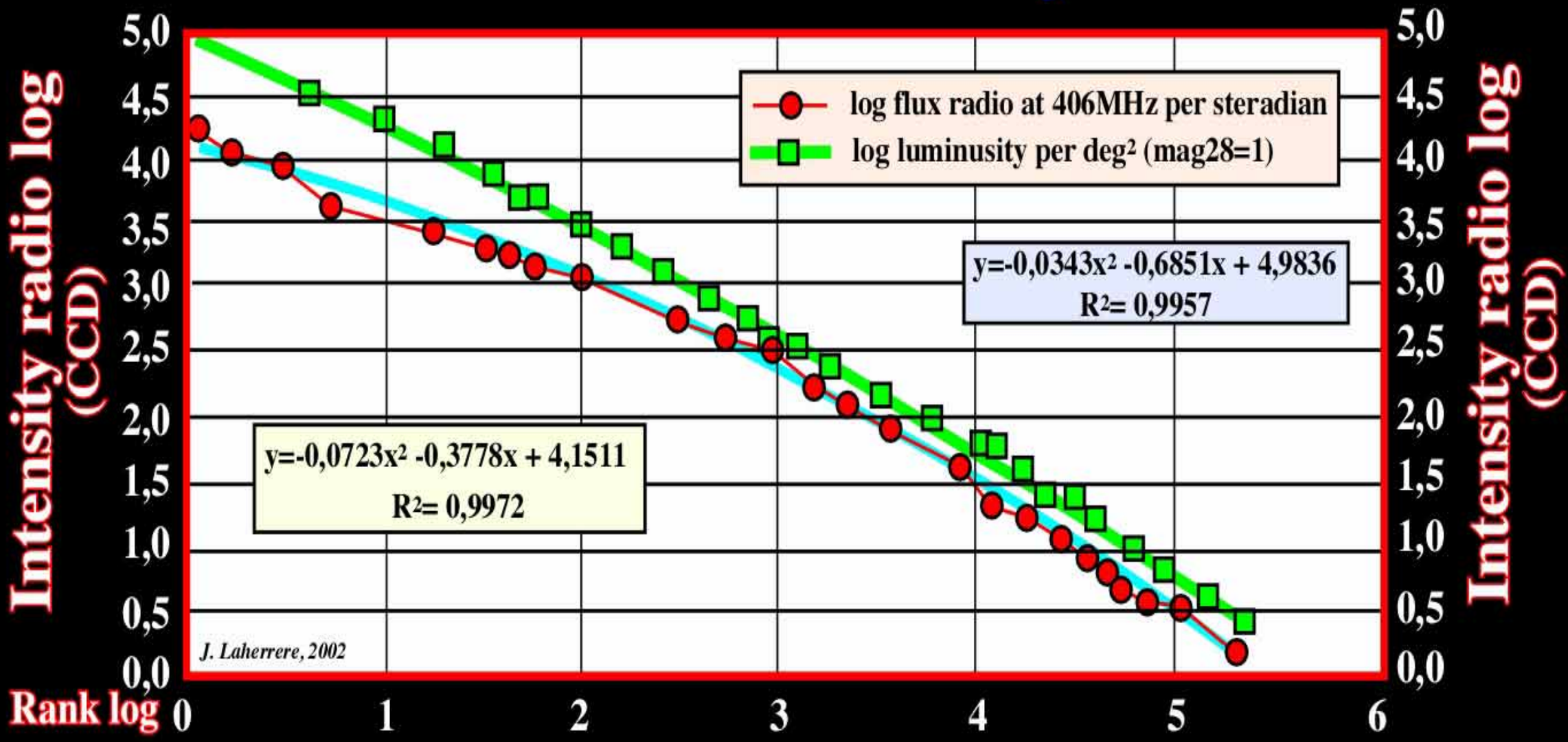
Massachusetts University, 2002

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.

C. Cramez, Switzerland
ccramez@compuserve.com

Fractal Distribution

Galactic Intensity

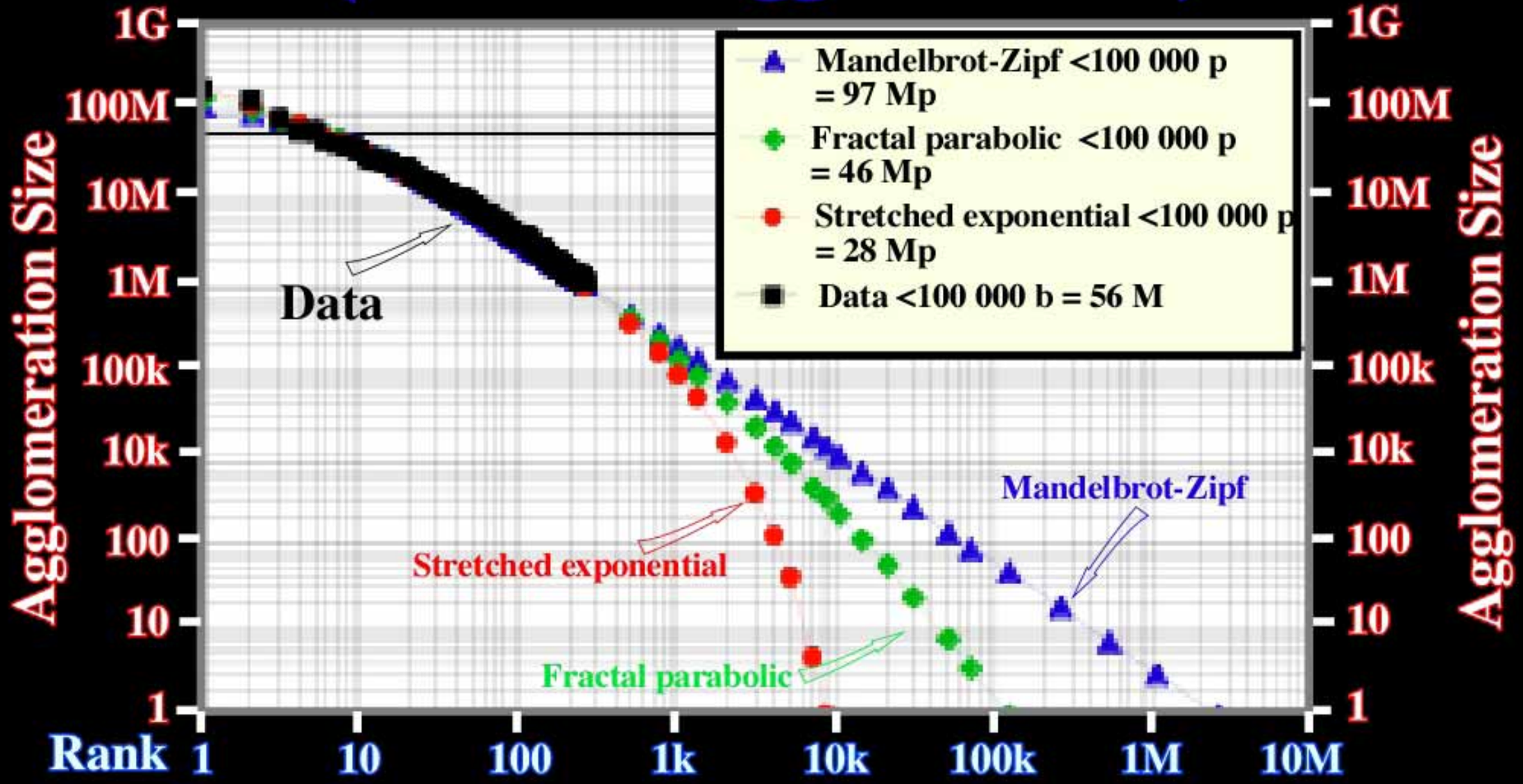


Indeed, as illustrated above, he galactic intensity (flux radio, luminosity) when listed in decreasing size (decreasing luminosity) and plotted on a log-log format, with size against rank, shows a fractal distribution. However, as illustrated next, several fractal parabolic curves can be considered.

C. Cramez, Switzerland
ccramez@compuserve.com

Fractal Distribution

(US Urban Agglomeration)

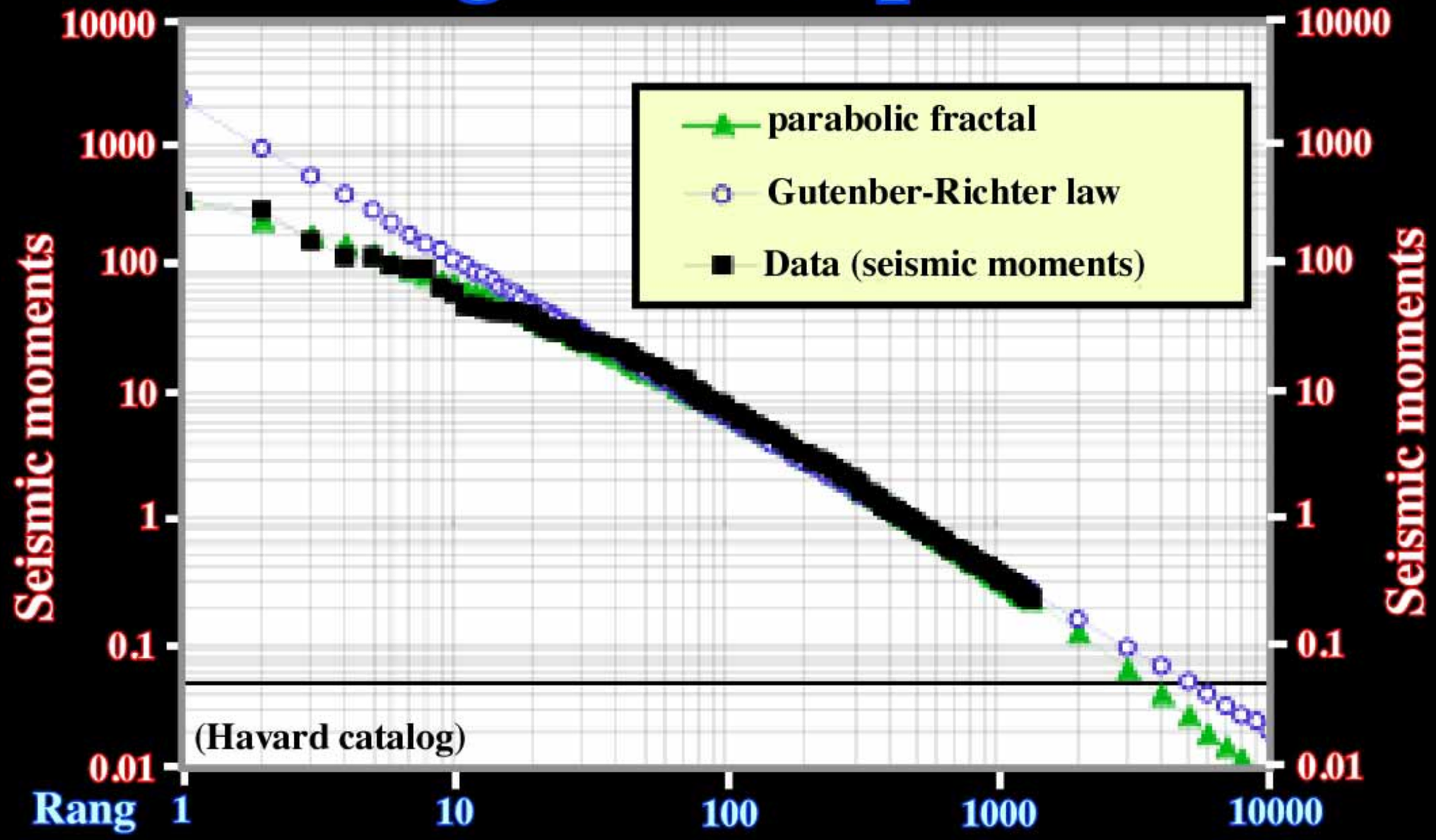


USA urban agglomeration were listed in decreasing size and plotted in a log-log display against rank. The data shows a fractal distribution. Several extrapolation are possible: (i) Mandelbrot-Zipf, (ii) Fractal parabolic and (iii) Stretched exponential. Perfect self-similarity is a power law or linear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

C. Cramez, Switzerland
ccramez@compuserve.com

Fractal Parabolic

Largest Earthquakes



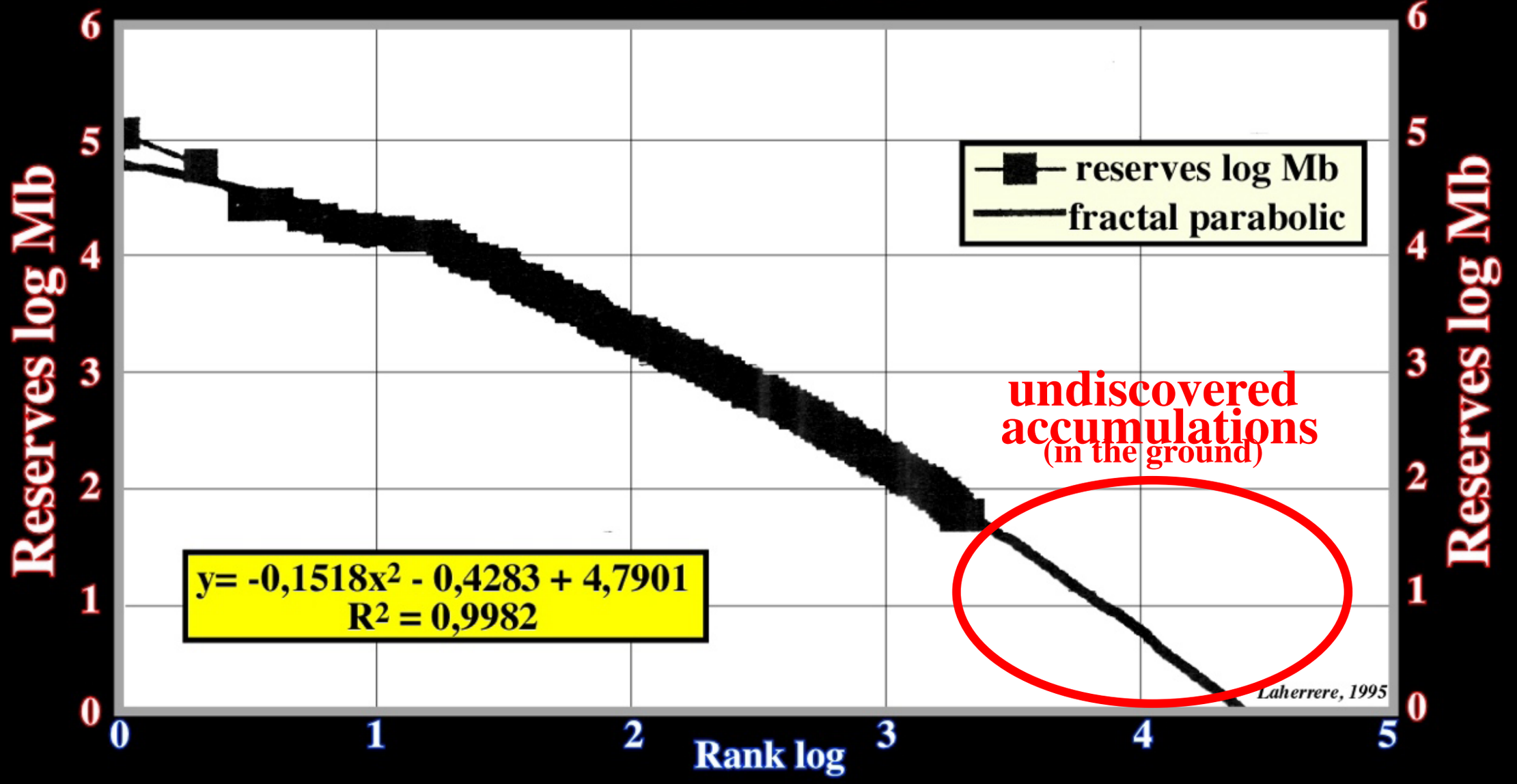
It is evident that in this particular exemple the best fit is parabolic fractal, at least for small and medium ranks. Similarly, in basinal turbidite depositional systems, the plot of thickness of the lobes against rank, on a log-log format, shows a parabolic fractal distribution.

C. Cramez, Switzerland
ccramez@compuserve.com

ASPO France

Fractal Parabolic

Reserves



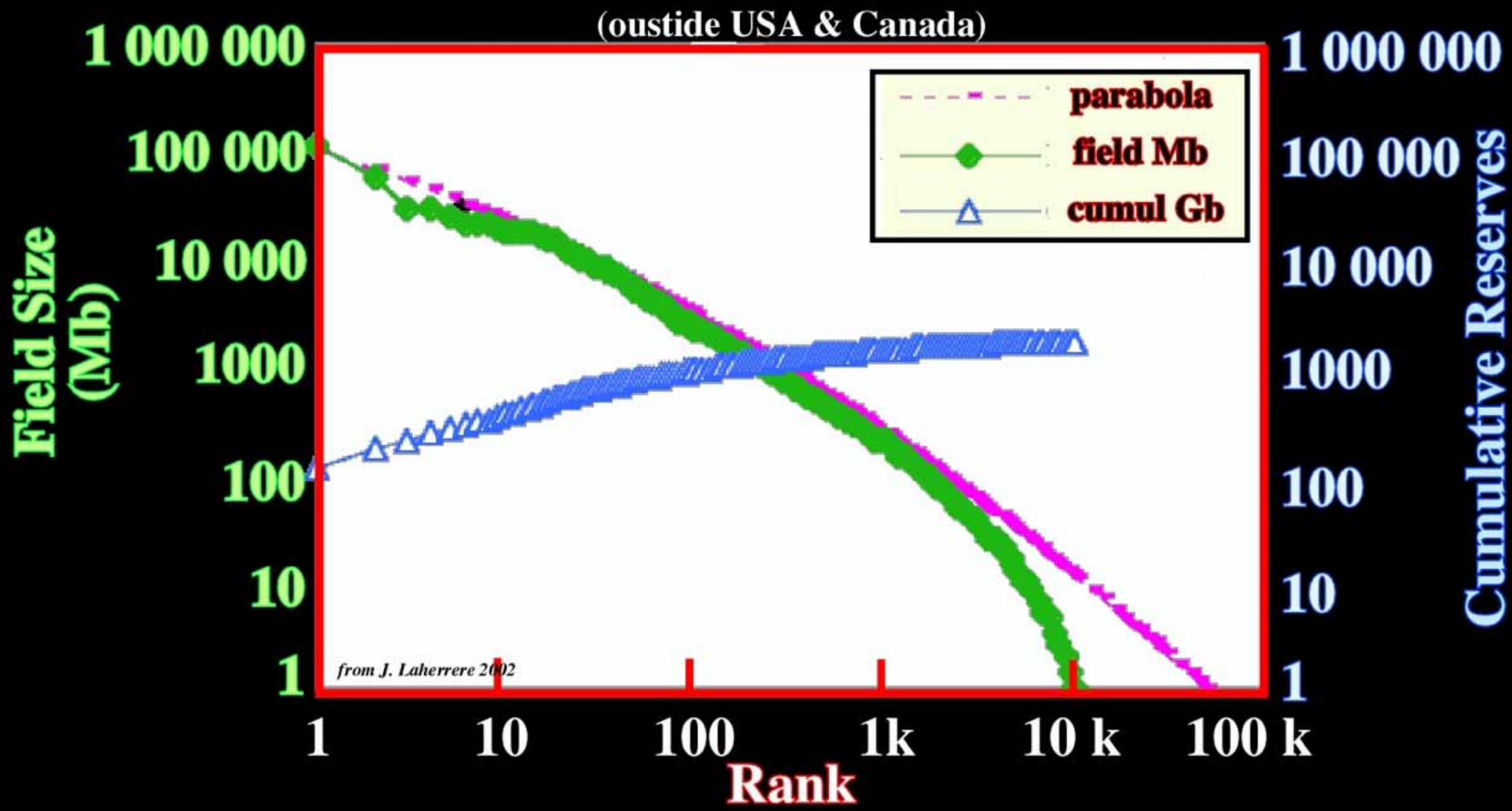
Plotting in a log-log display, reserves versus rank shows also a fractal distribution. The fractal parabolic curve allows geoscientists to predict, roughly, undiscovered accumulations. Such a distribution, which also observed in single petroleum basins allows to determine the degree of maturation of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

C. Cramez, Switzerland
ccramez@compuserve.com

ASPO France

Fractal Parabolic

Oil Fields Size



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.

C. Cramez, Switzerland
ccramez@compuserve.com

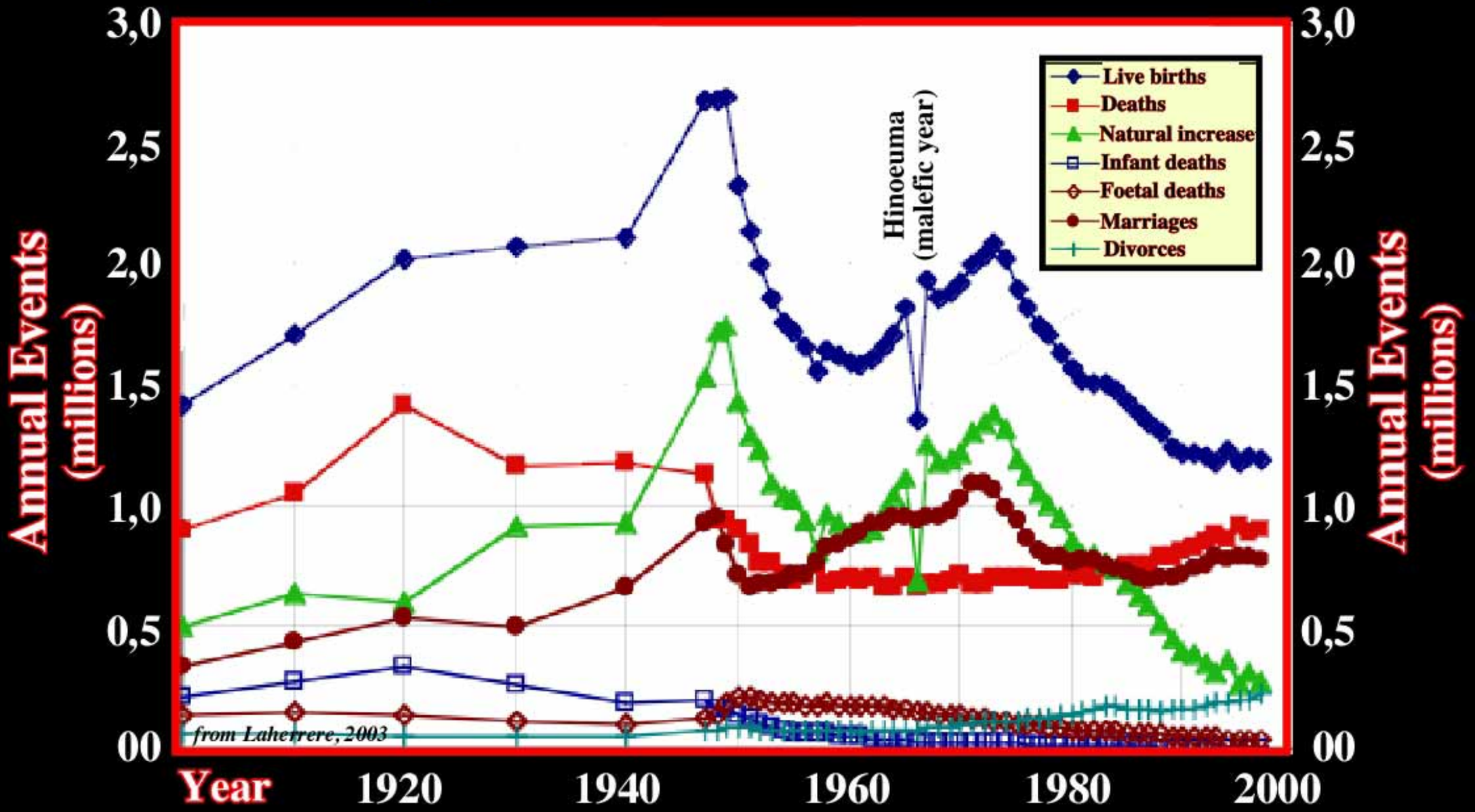
Cyclicity

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

C. Cramez, Switzerland
ccramez@compuserve.com

Cyclicity

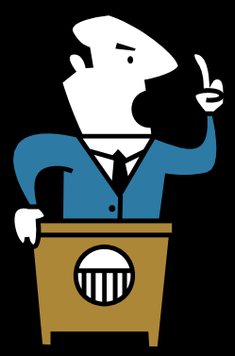
Japan Annual Events



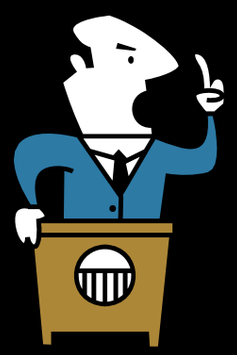
Live births, deaths, natural increase, infant deaths, foetal deaths, marriages, divorces, that is to say, natural events are cyclic. In Japan annual events, an anomaly must be taken into account, in 1968/1970, the Hinouema or the malefic year.

C. Cramez, Switzerland
ccramez@compuserve.com

Cyclicity



Nothing is eternal



What is born will die

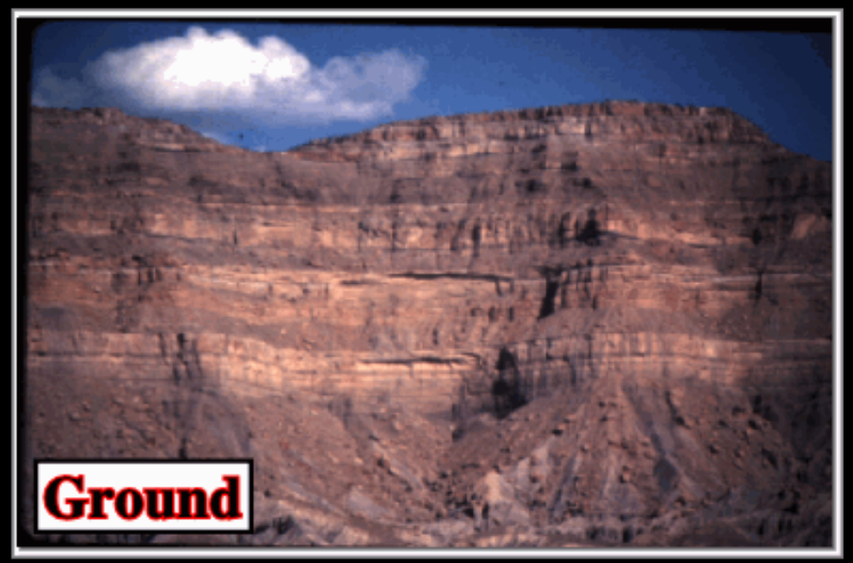
What goes up will come down

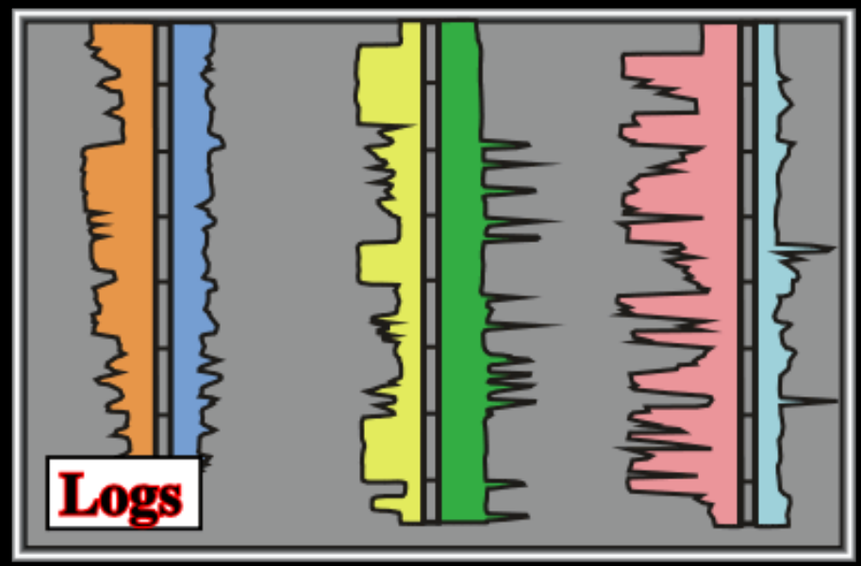
Sun, earth, mankind, civilisation, etc. will die.

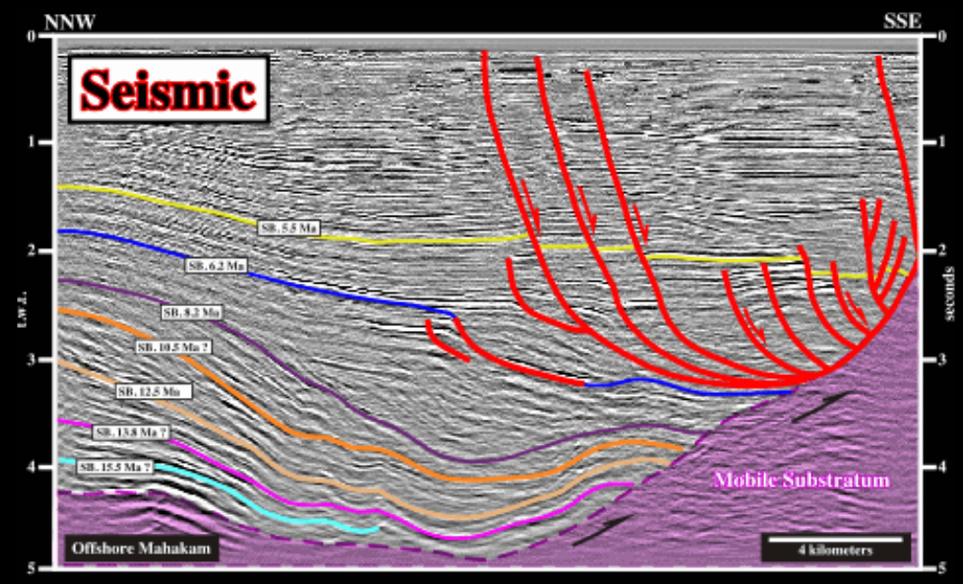
C. Cramez, Switzerland
ccramez@compuserve.com

Cyclicity

Depositional Systems are Cyclic







Since long time, geoscientits notice the cyclicity 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 cyclicity of the depositional systems.

C. Cramez, Switzerland
ccramez@compuserve.com

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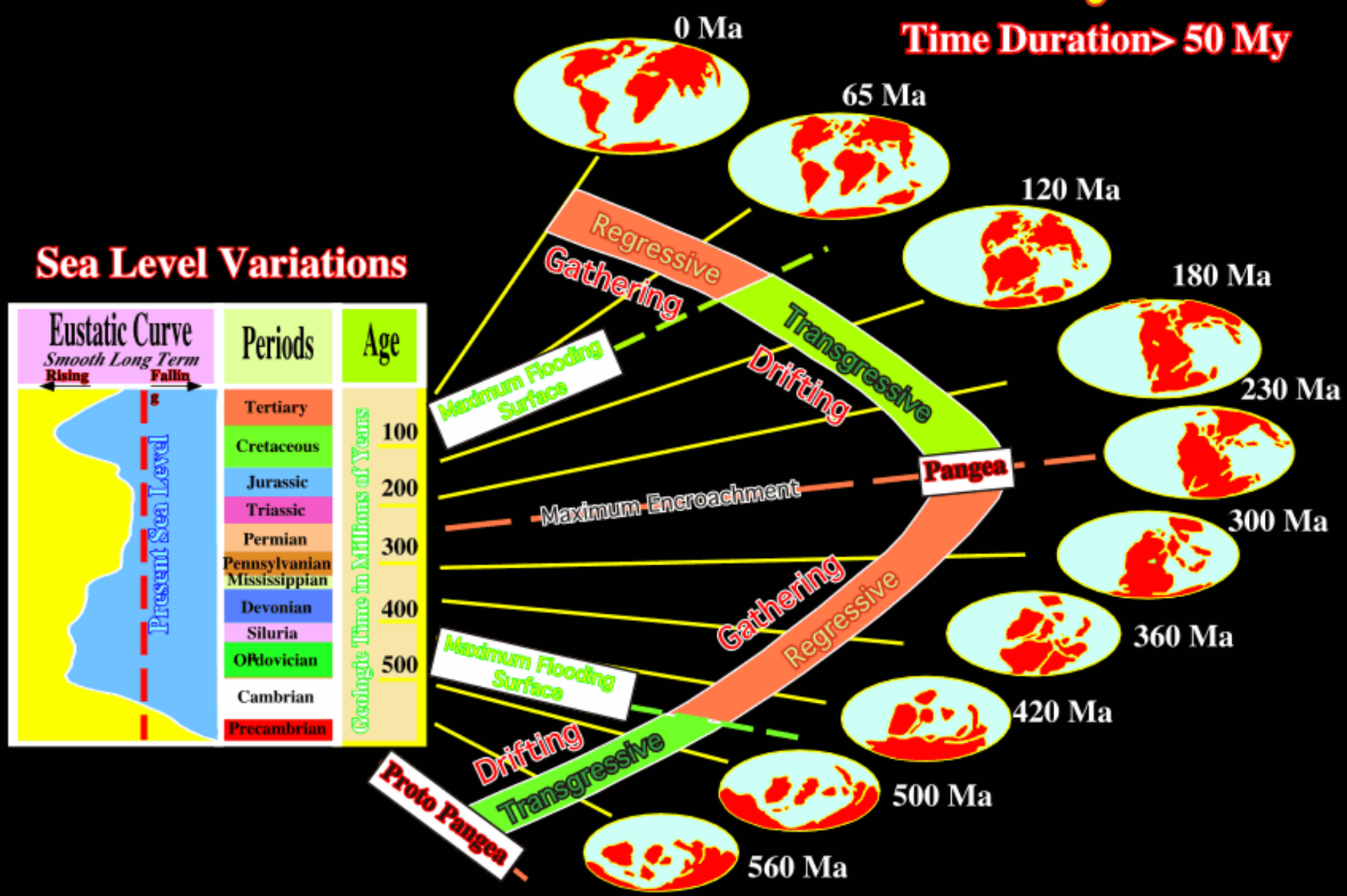
Cyclicity

Continental Encroachment Cycles

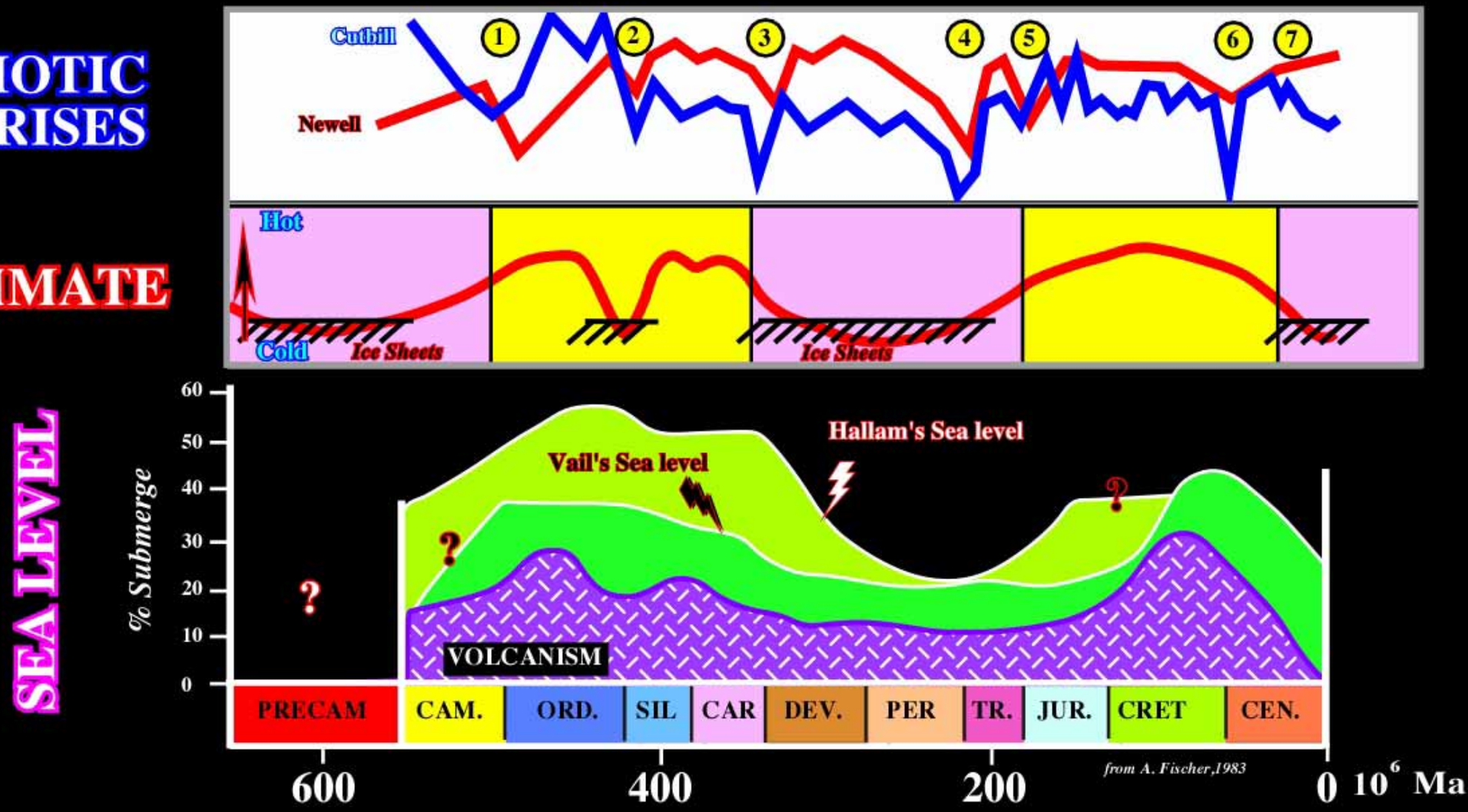


The Earth's history, at least since Phanerozoic (600 Ma), can be depicted as cyclic. After the gathering of the Proto-Pangea supercontinent, it broke in several continents, which dispersed to a maximum, by sea floor spreading, before gathered, again, to form the Pangea. Then, the Pangea broke up in several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

C. Cramez, Switzerland
ccramez@compuserve.com

Cyclicity

Major Geologic Events are Cyclic



The Plate Tectonics paradigm, which is a cyclic theory, explains quite well the correlation between major geologic events, which are interlinked and interconneted. Indeed, they cannot be understood in isolation. A sytemic, 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.

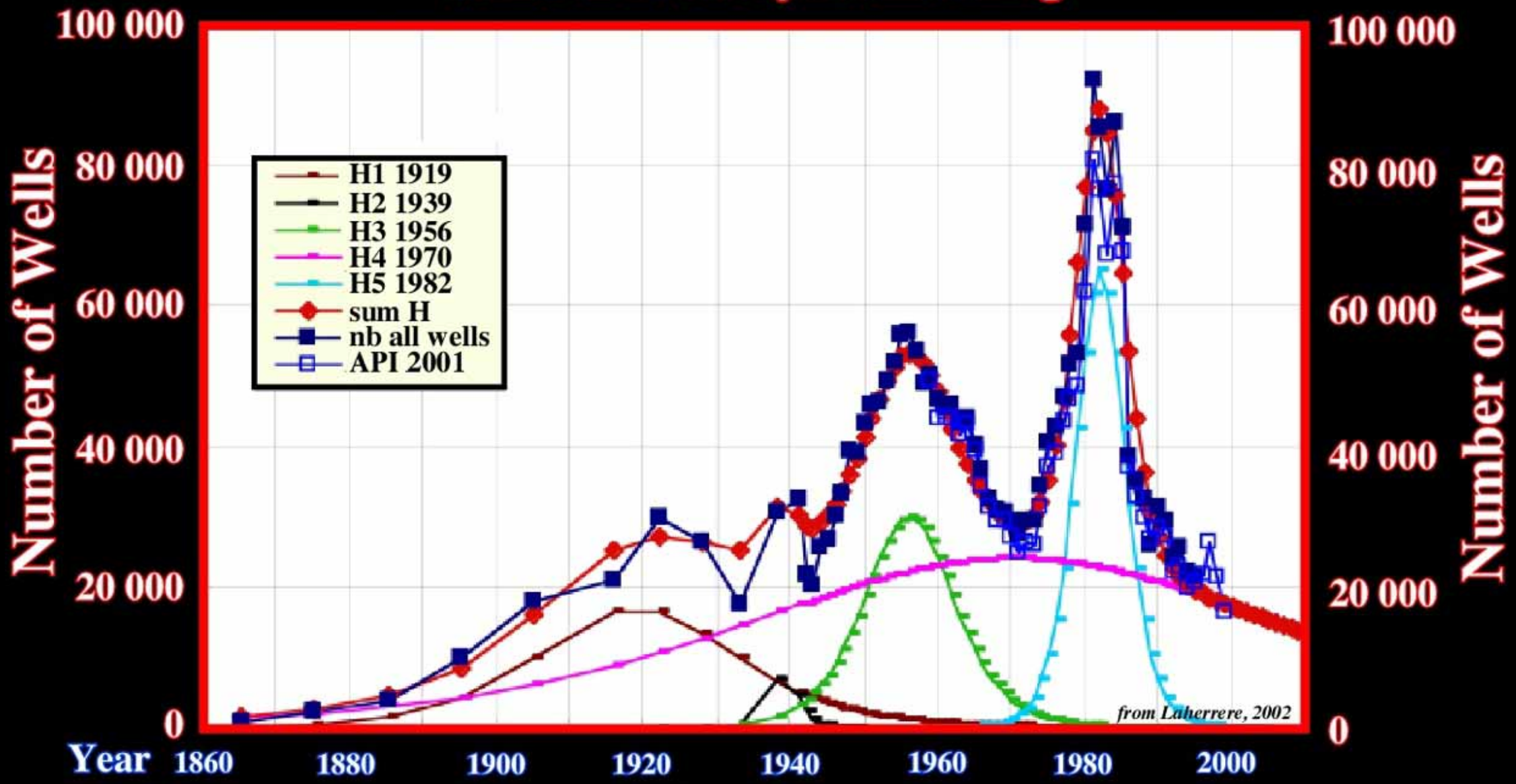
C. Cramez, Switzerland
ccramez@compuserve.com

ASPO France

Cyclicity

USA Drilling (all wells)

with 5 Hubbert cycles modeling

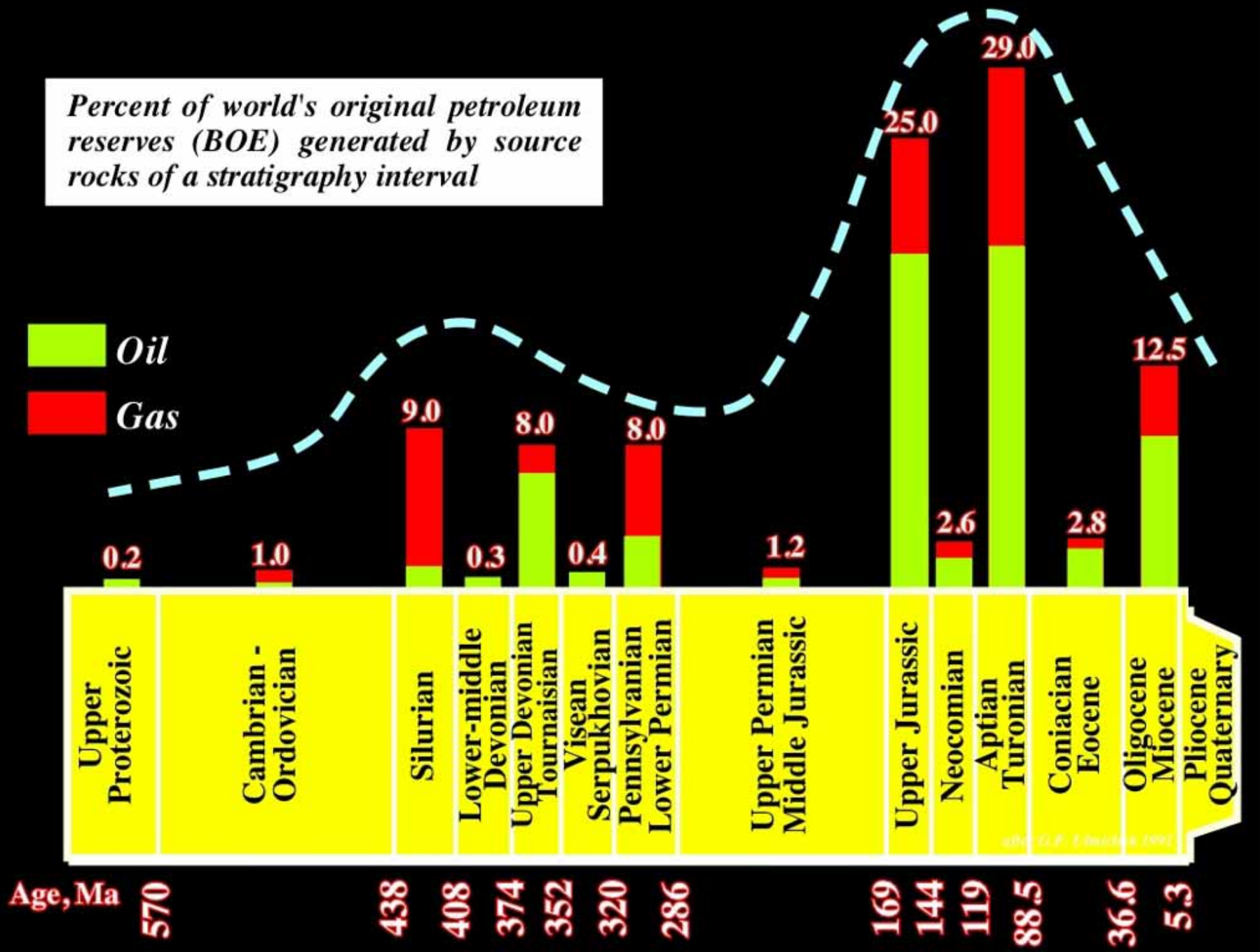


The number of wells drilled in petroleum exploration, as all natural events, seems to be cyclic, as suggested by this plot (nº of wells drilled per year). Such a cyclicity can be due to demand problems, new plays (turbidite depositional systems), new technology (deepwater drilling or seismic acquisition), etc.

C. Cramez, Switzerland
ccramez@compuserve.com

ASPO France

Cyclicity



The stratigraphic distribution of the source rocks, as the majority of geological features, shows a sharp cyclicity, 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.

C. Cramez, Switzerland
ccramez@compuserve.com

Finiteness

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

C. Cramez, Switzerland
ccramez@compuserve.com

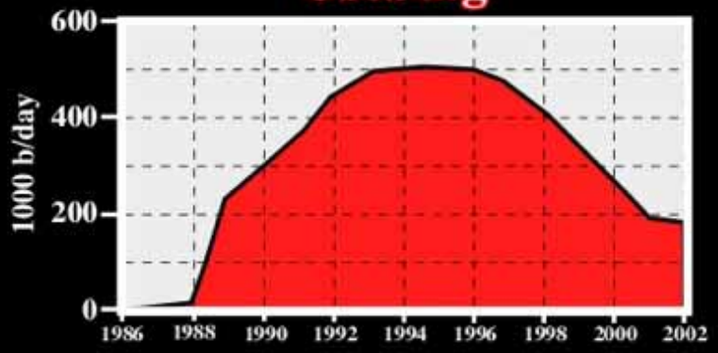
Finiteness

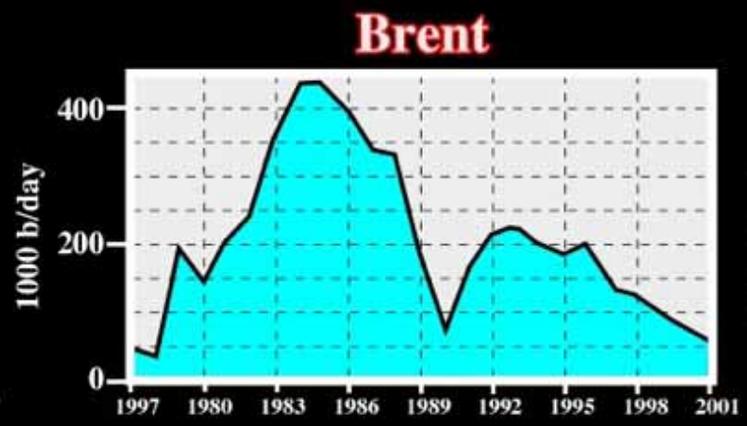
In the Nature, there is no permanent growth, that is to say, all which is born, has to die, or all which rises, has to come down again.

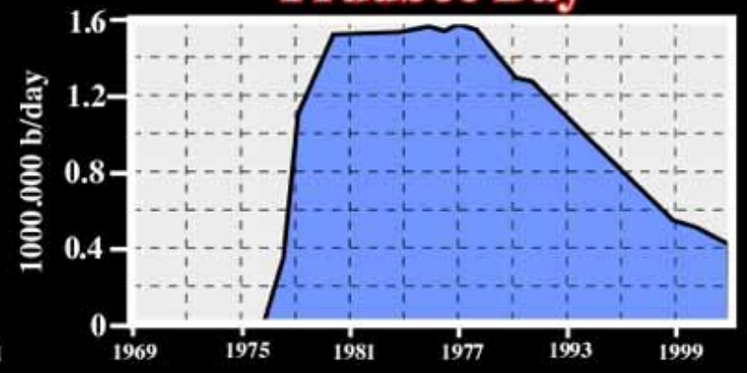
Suppose a bacteria doubling every 30 minutes. After one week all Solar System will be filled, and after 11 days all Universe will be filled.

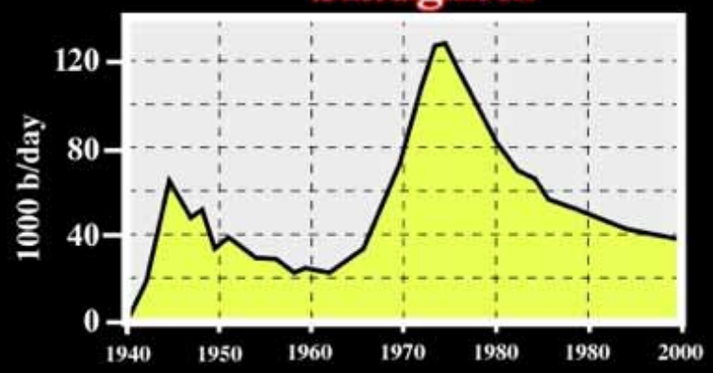
C. Cramez, Switzerland
ccramez@compuserve.com

Finiteness

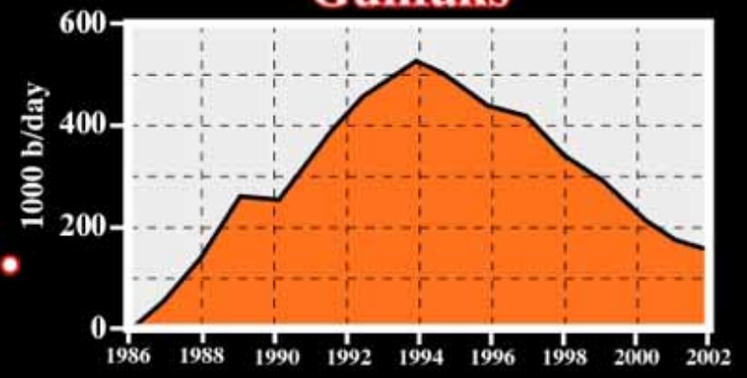


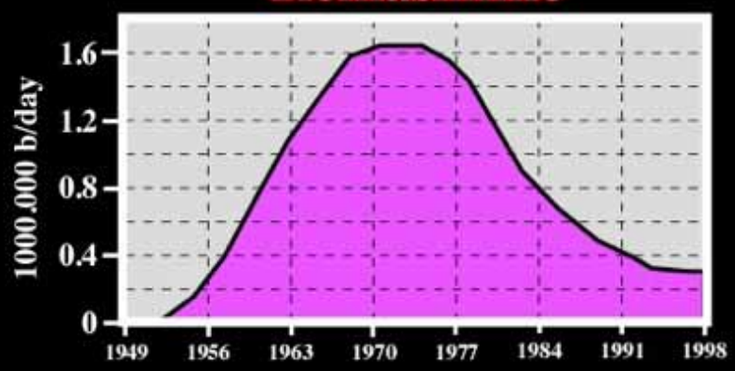


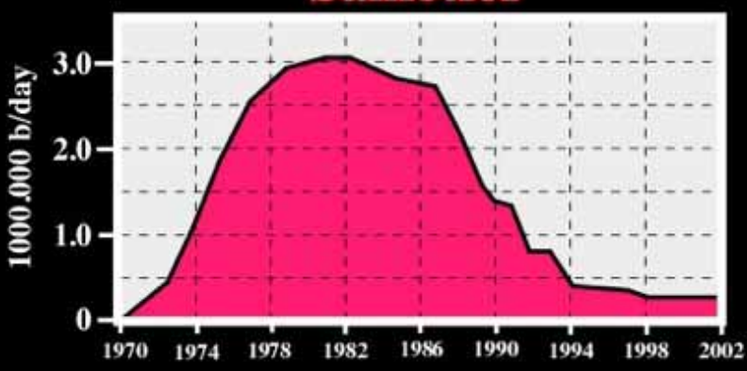




All oil fields after reaching a peak production decline.







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).

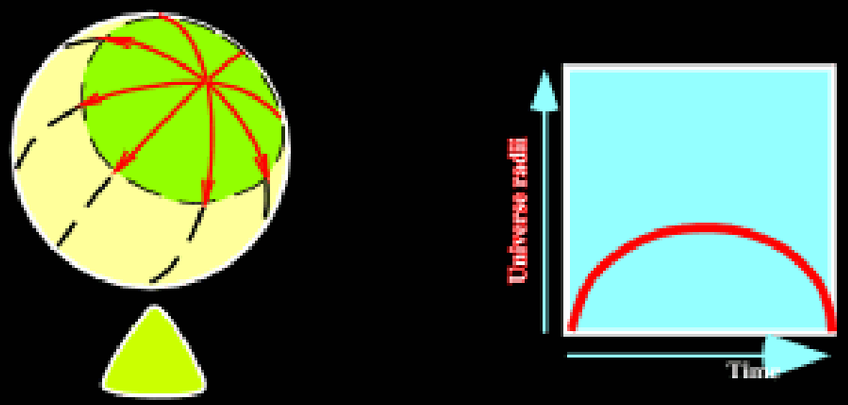
Finiteness

Three spaces are possible in relativity:

1) No curvature,
2) Positive curvature,
3) Negative curvature.

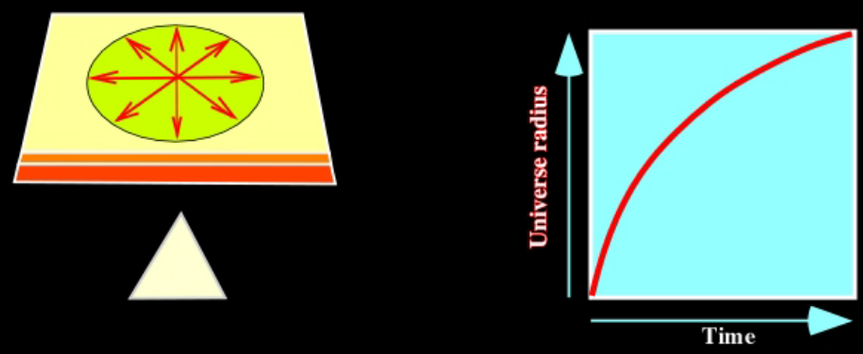
2) Positive curvature

Closed Universe



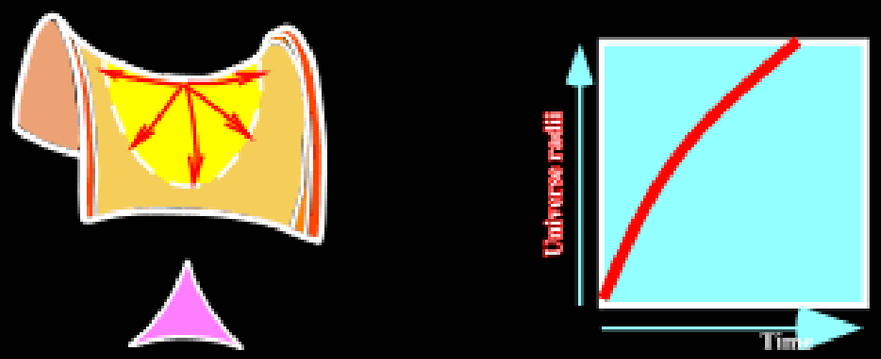
1) No curvature

Flat Universe



3) Negative curvature

Open Universe



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

C. Cramez, Switzerland
ccramez@compuserve.com

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?

C. Cramez, Switzerland
ccramez@compuserve.com

There is a large number of solution:

There are 14 solutions (1st degree)

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

C. Cramez, Switzerland
ccramez@compuserve.com

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In Nature, too simple is often false

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

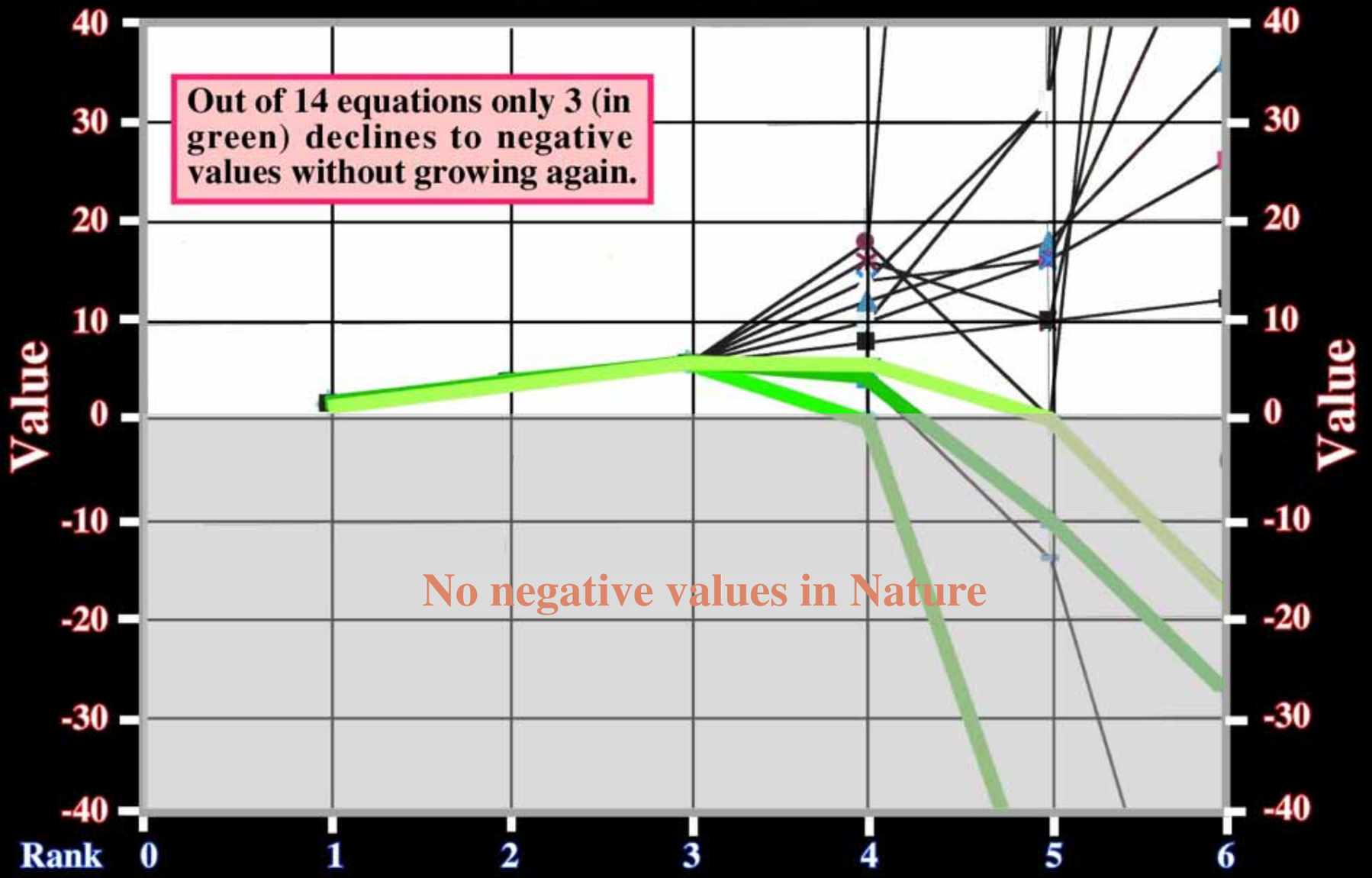
Continuous growth is impossible in Nature

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

C. Cramez, Switzerland
ccramez@compuserve.com

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.

C. Cramez, Switzerland
ccramez@compuserve.com

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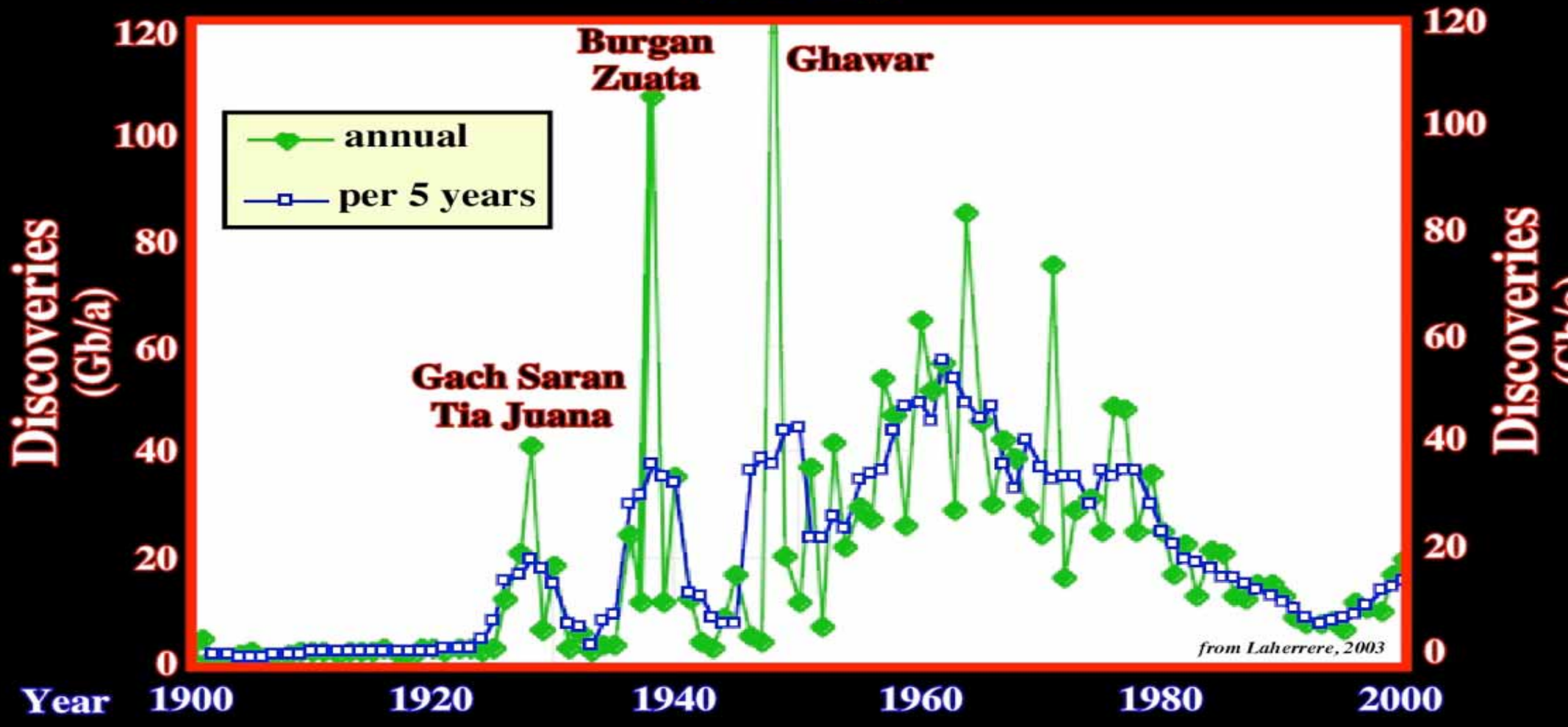
The simplest natural answer is

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)



C. Cramez, Switzerland
ccramez@compuserve.com

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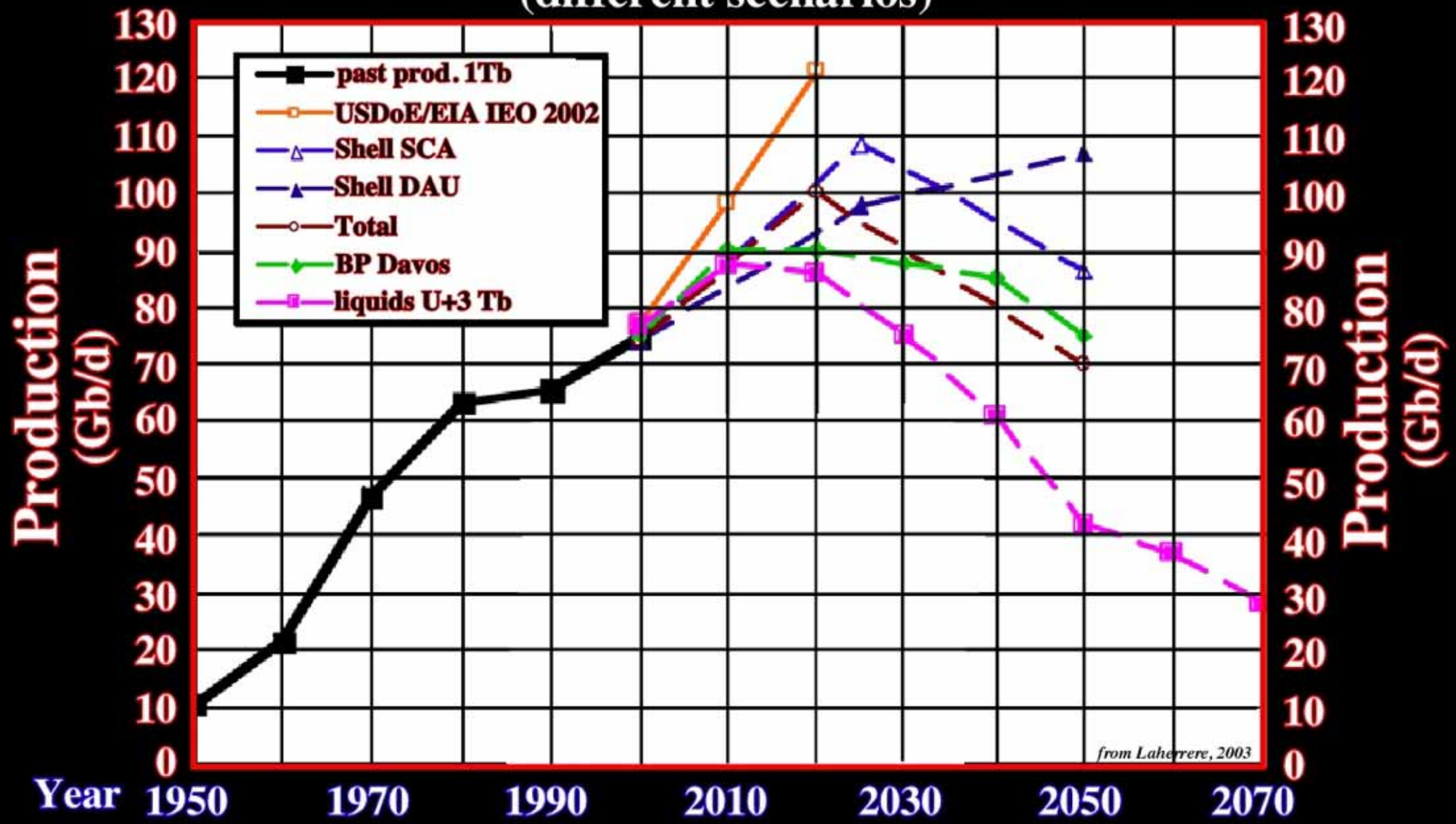
Finiteness

World Oil Production

(different scenarios)



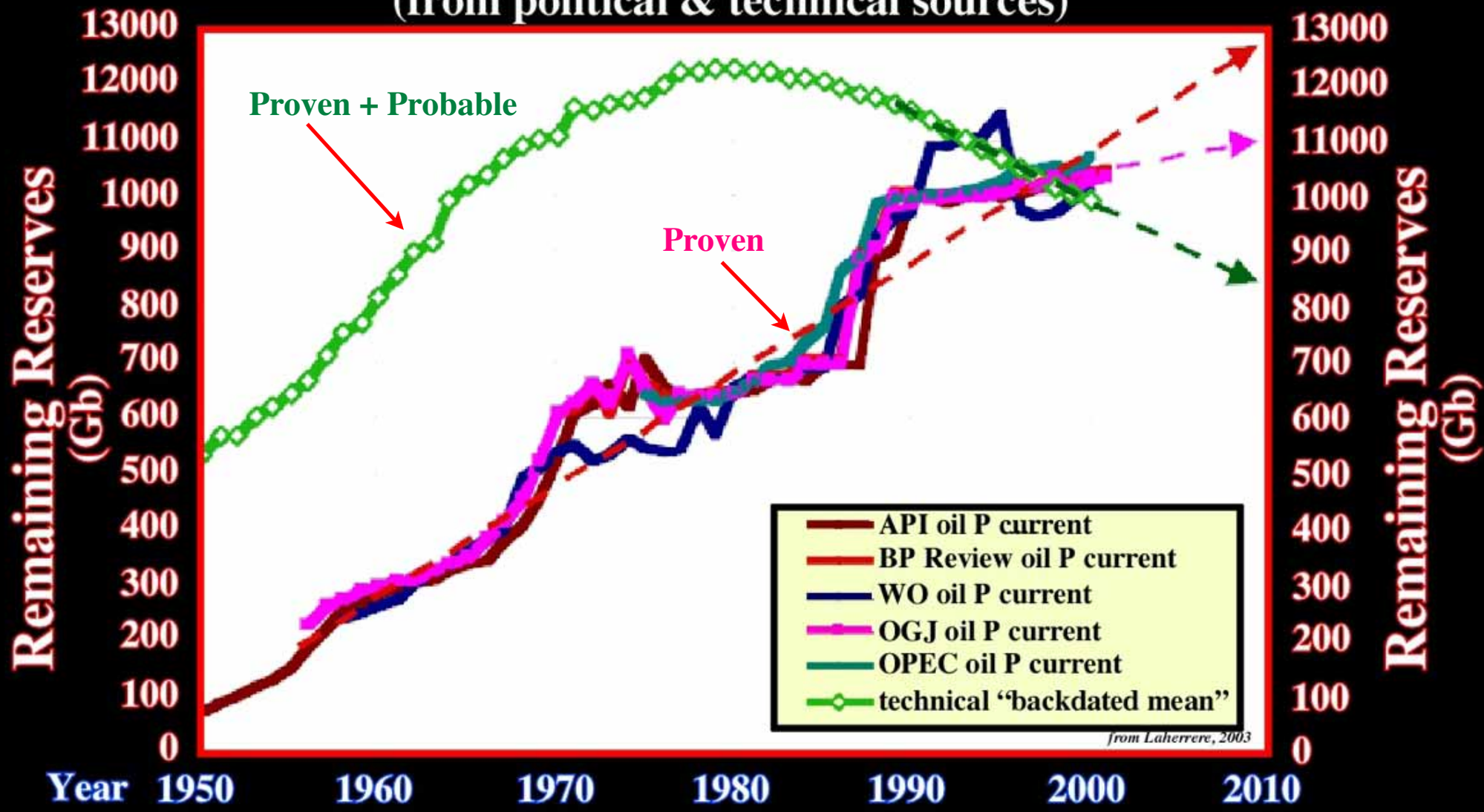
Assuming that when oil production peaks half of the reserves have already been produced, one can said that cheap oil is finished. Probably, very soon, if not already, we will be in left part of the purple curve. The discrepancies between the curves are artificial; lot of them are based in political and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

C. Cramez, Switzerland
ccramez@compuserve.com

Finiteness

World: Oil remaining Reserves

(from political & technical sources)



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

C. Cramez, Switzerland
ccramez@compuserve.com

Gravitation

Everything is curved.
Linearity exists only locally

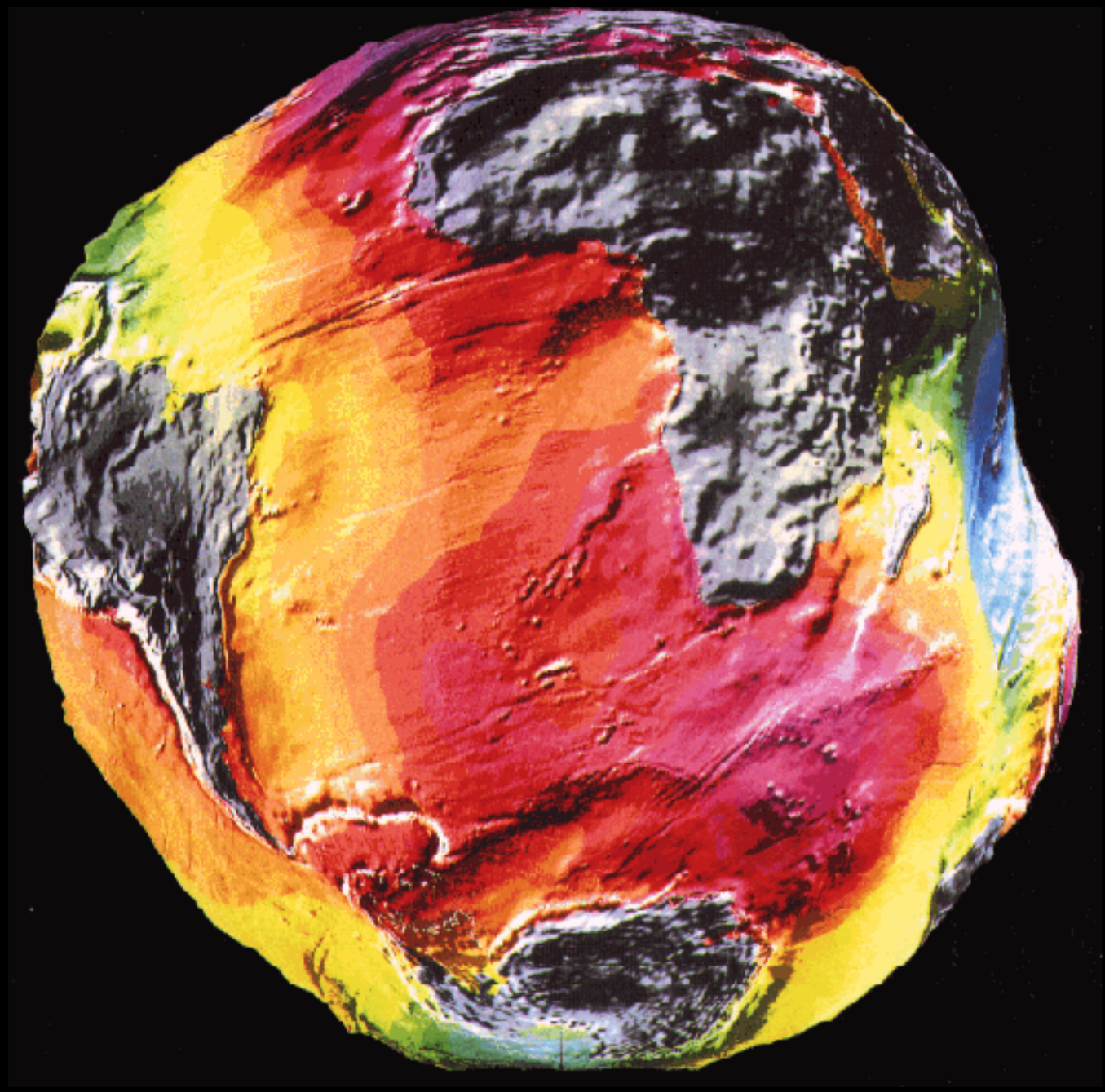
To picture the solar system think of space-time as a rubber sheet with the Sun as a heavy ball and planets as a marble place on it. This is Einstein's model of the way matter curves space-time and helps visualise the force of gravity between masses.

C. Cramez, Switzerland
ccramez@compuserve.com

Gravitation

Gravity Anomalies

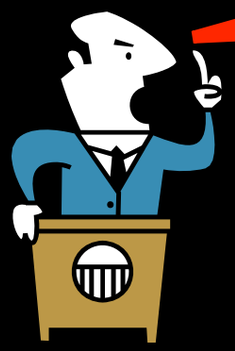
The geoid is the most graphical representation of the Earth gravity field. The largest positive geoid heights are associated with subduction zones and hotspots and have no simple relationship to other high regions such as continents and ridges. Subsequently, as sea level is not uniform, a global rise 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

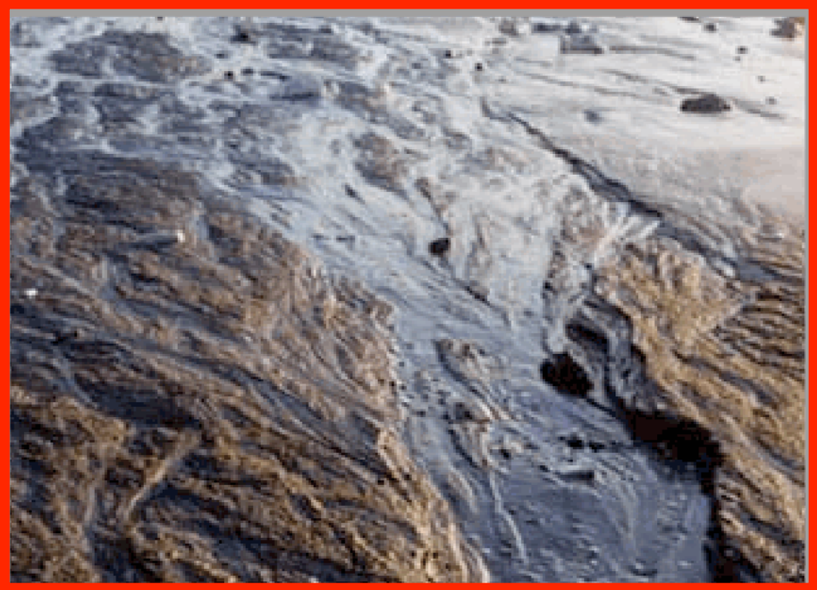
C. Cramez, Switzerland
ccramez@compuserve.com

All clastic sediments are deposit by gravity



Yes, I see

Braided-streams



Eolian deposits

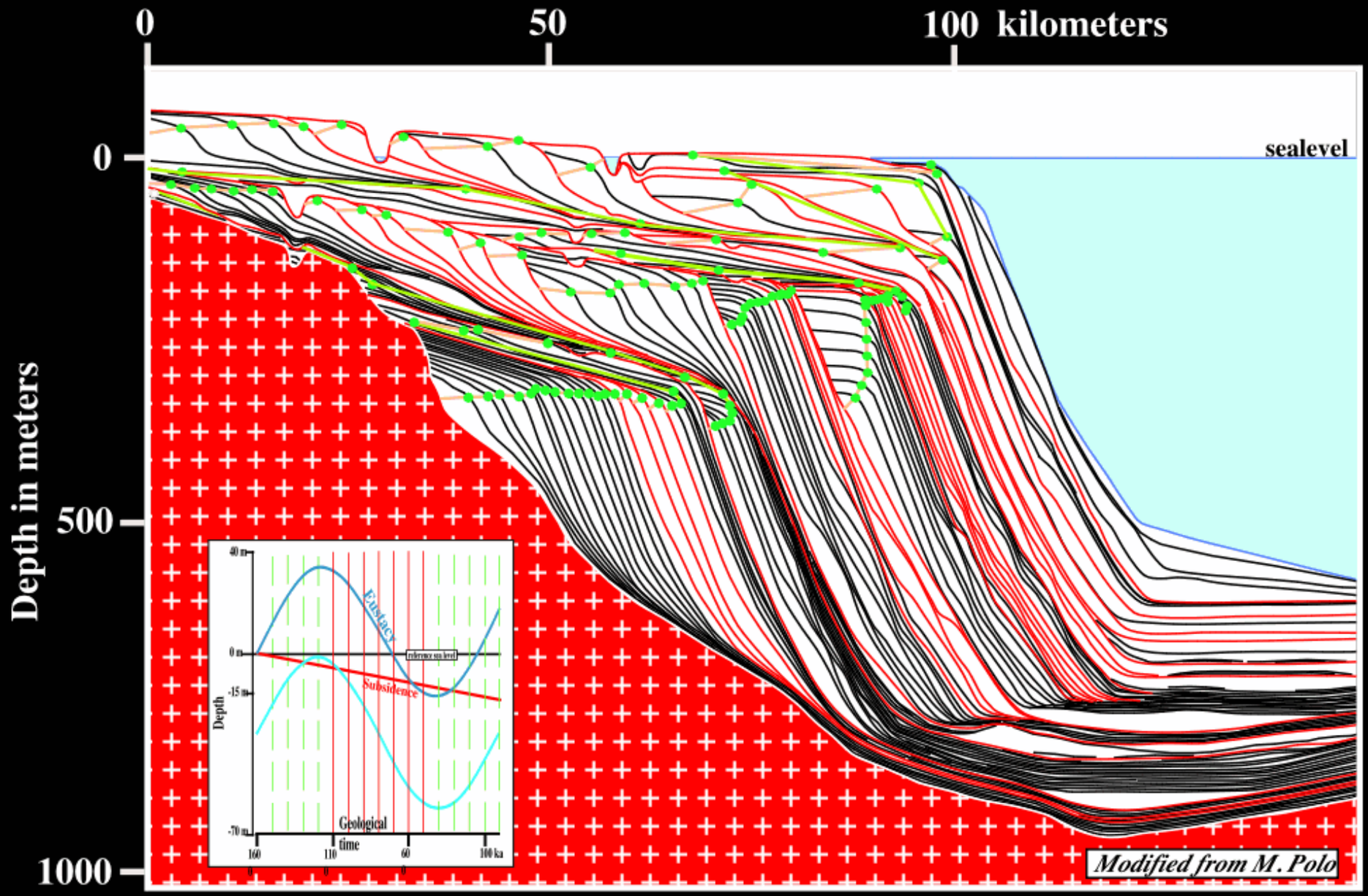
Pyroclastis deposits

Snow deposits

C. Cramez, Switzerland
ccramez@compuserve.com

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. Terrigeneous 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.

C. Cramez, Switzerland
ccramez@compuserve.com

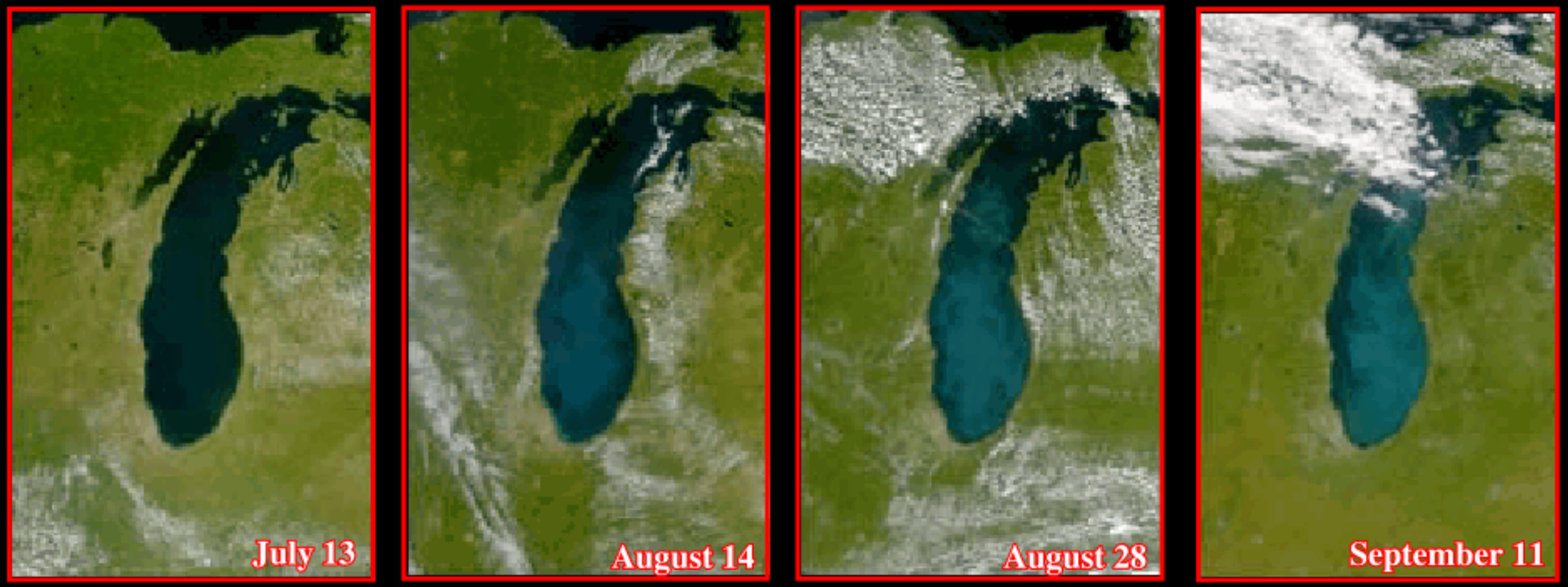
Life

Life is everywhere

C. Cramez, Switzerland
ccramez@compuserve.com

Life

Lake Michigan

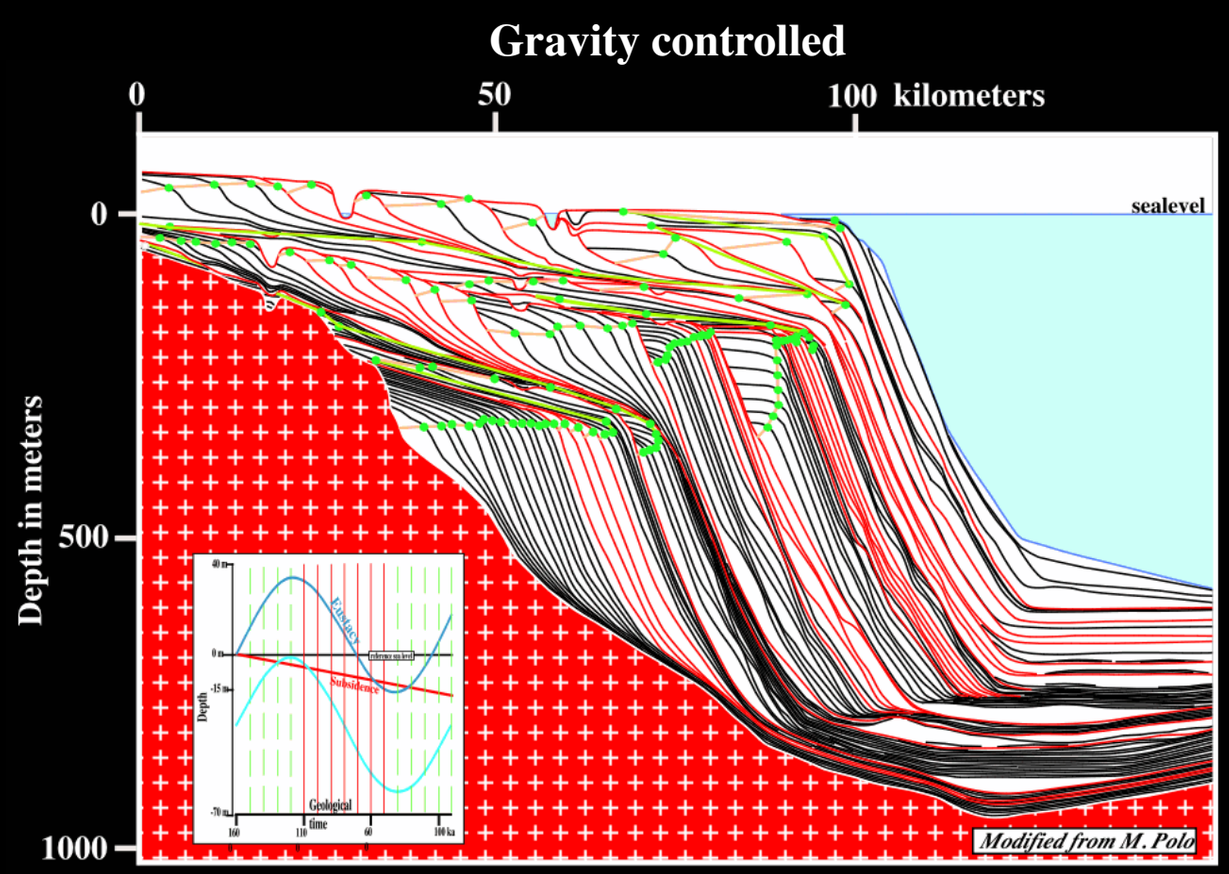


The bright color that appears in late summer in Lake Michigan is caused by the calcium carbonate in the water and not by life. Lake Michigan always has a lot a calcium carbonate because the floor of the lake is limestone. During most of the year the calcium carbonate remains dissolved in the cold water,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

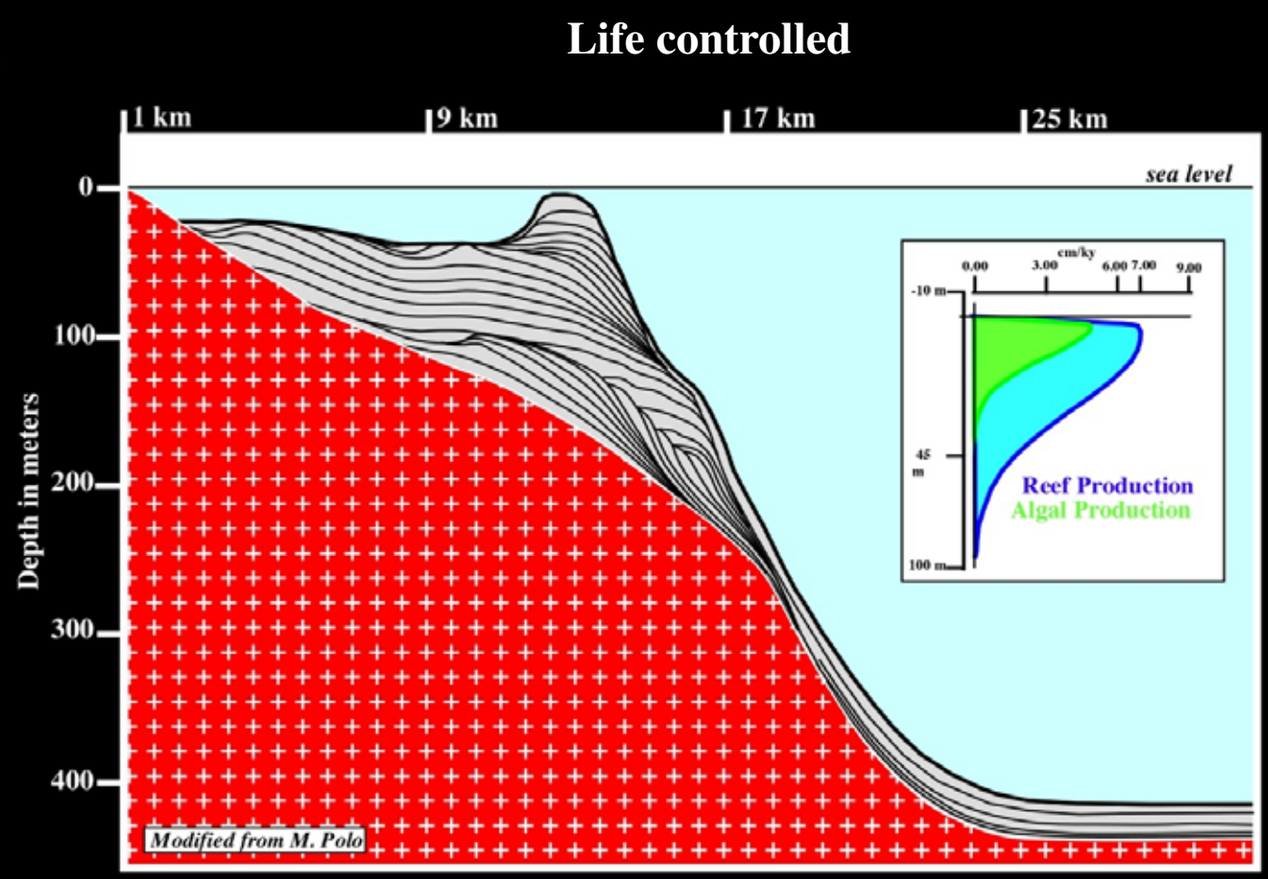
C. Cramez, Switzerland
ccramez@compuserve.com

Life & Gravity control sedimentation

Vail's model for clastics



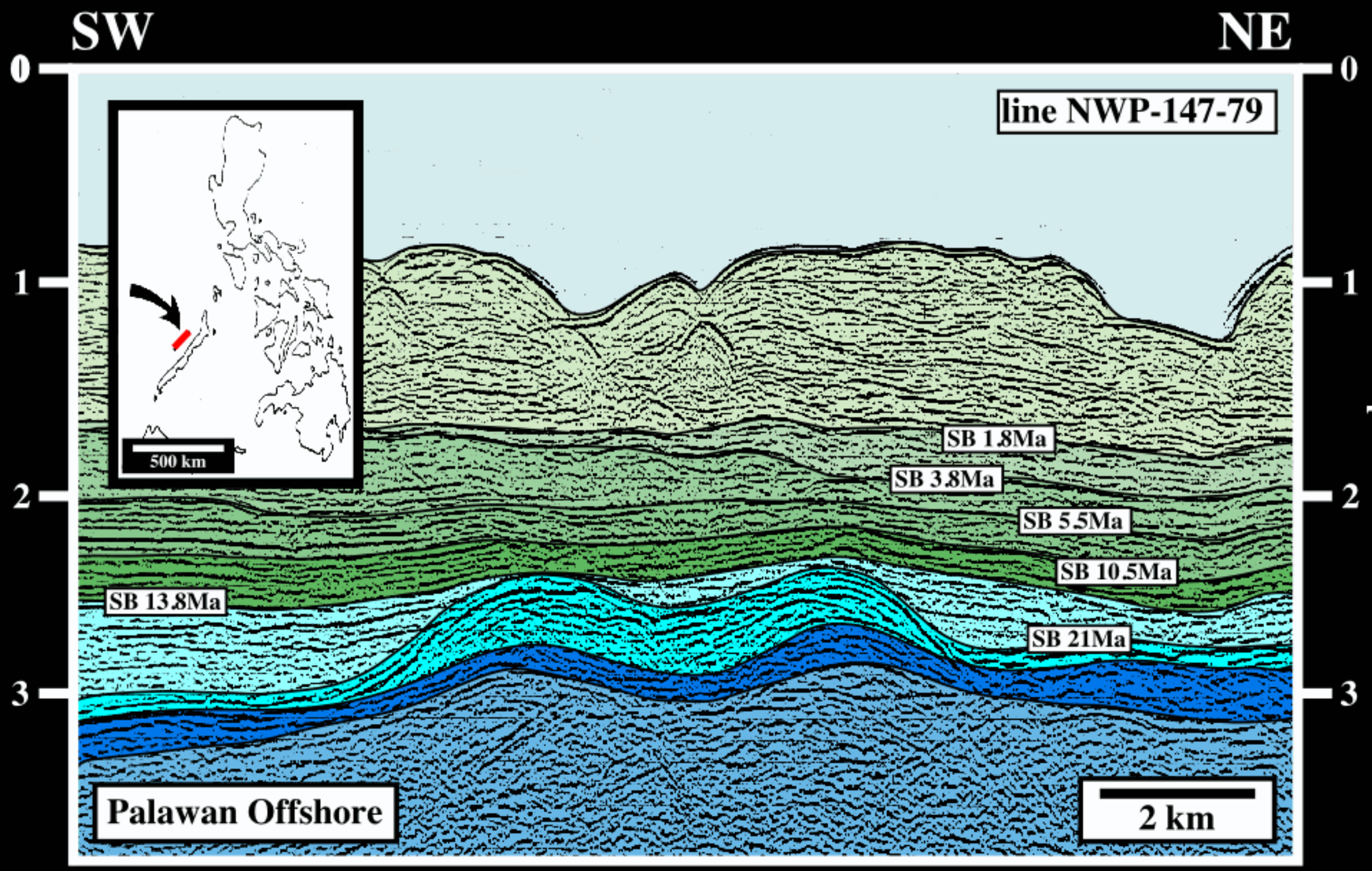
Vail's model for carbonate



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 terrigeneous 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.

C. Cramez, Switzerland
ccramez@compuserve.com

Carbonate Buildups



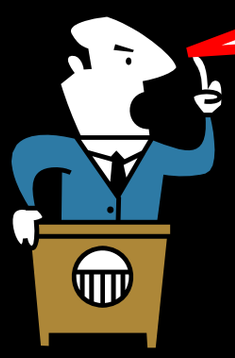
Carbonate buildups, as those illustrated on this line from off as other organic rocks obey to the three basic principles controlling life that we will review next.

C. Cramez, Switzerland
ccramez@compuserve.com

Life

Life is controlled by three major laws.

Life



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.

C. Cramez, Switzerland
ccramez@compuserve.com

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Fermat-Maupertius's law

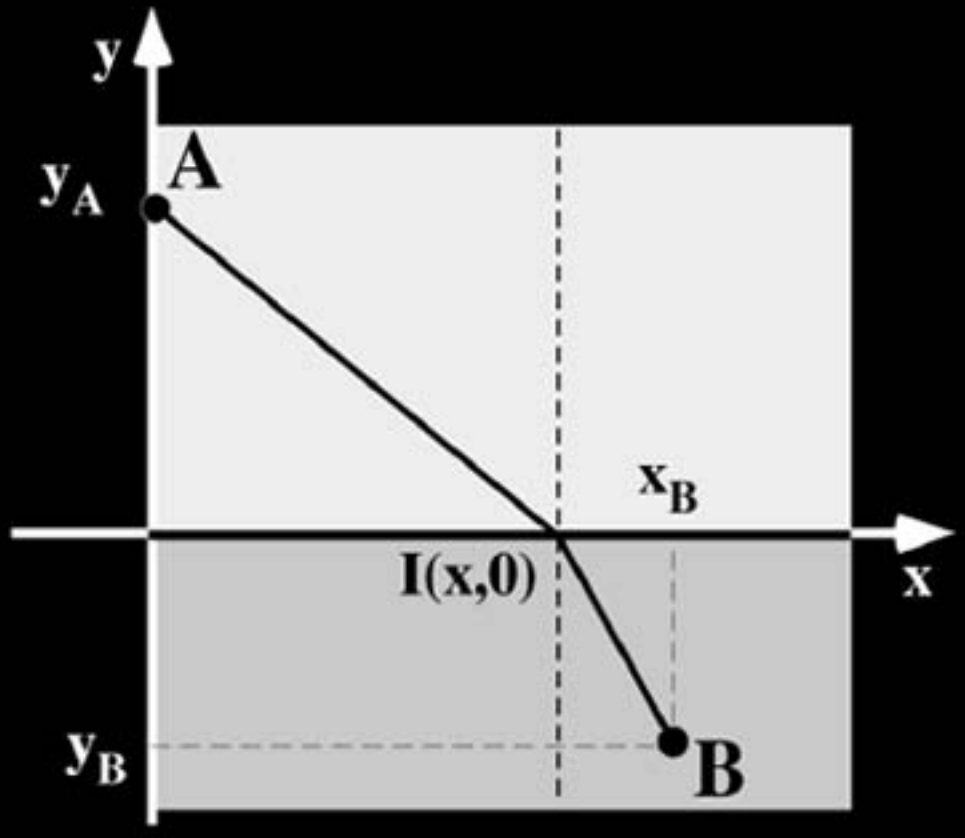
(Principle of Minimum Action)

"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).



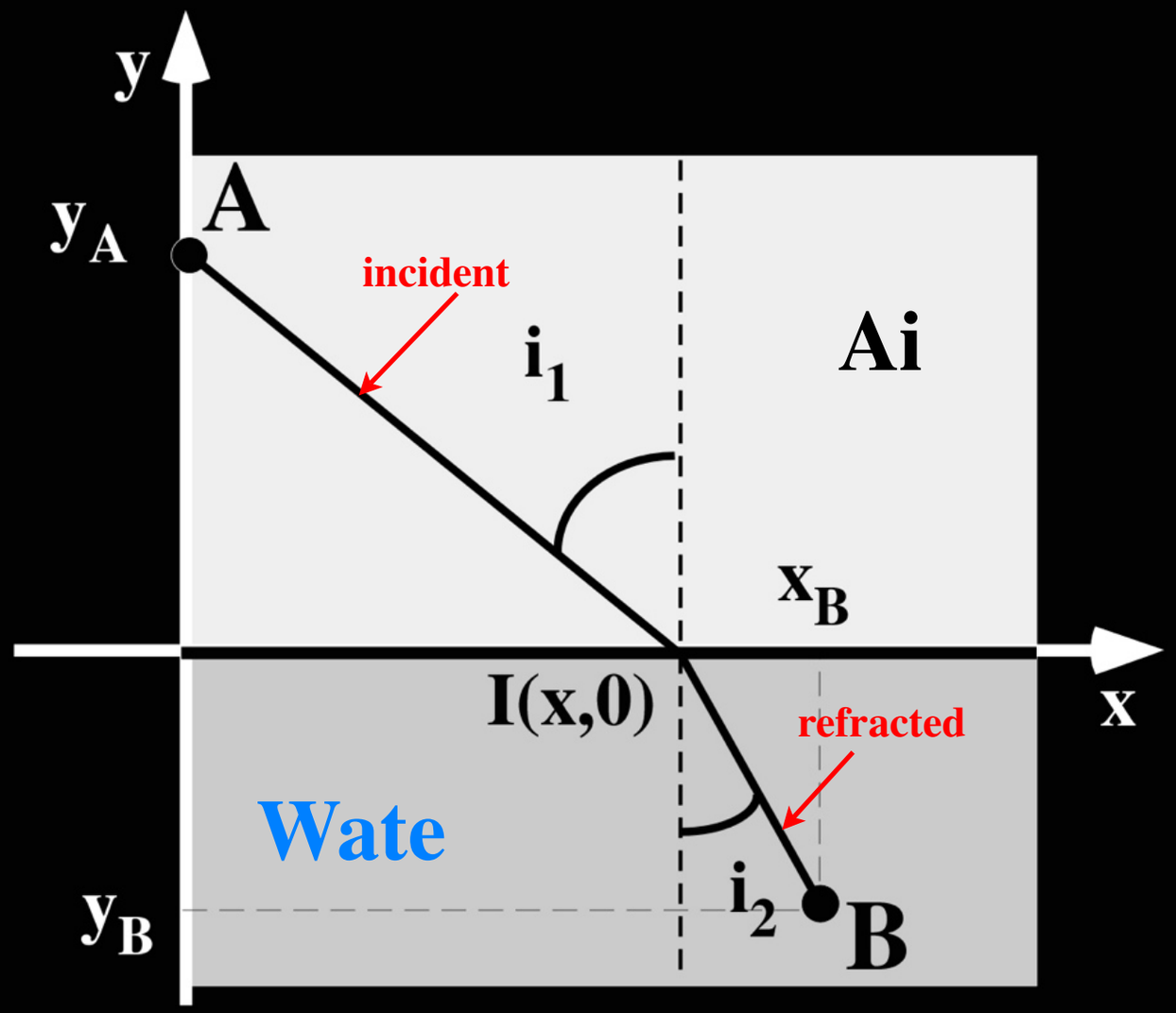
C. Cramez, Switzerland
ccramez@compuserve.com

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.



C. Cramez, Switzerland
ccramez@compuserve.com

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.

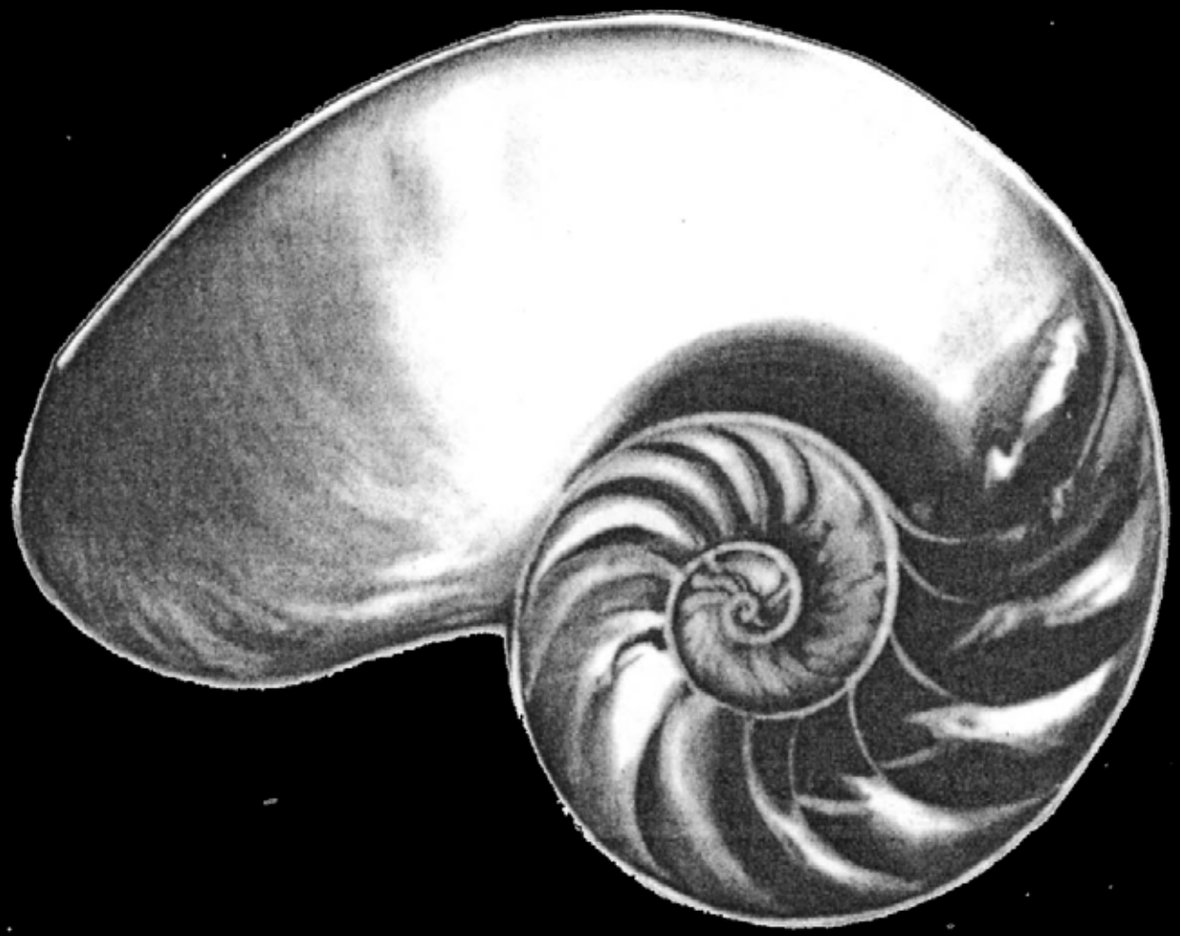
This simple pattern can determine the shape of a seashell, pine-cones or the sprouting of leaves from the stem of any plant. This connection to the organic world is reflected in the surface pattern, which is achieved through the process of smoke firing.

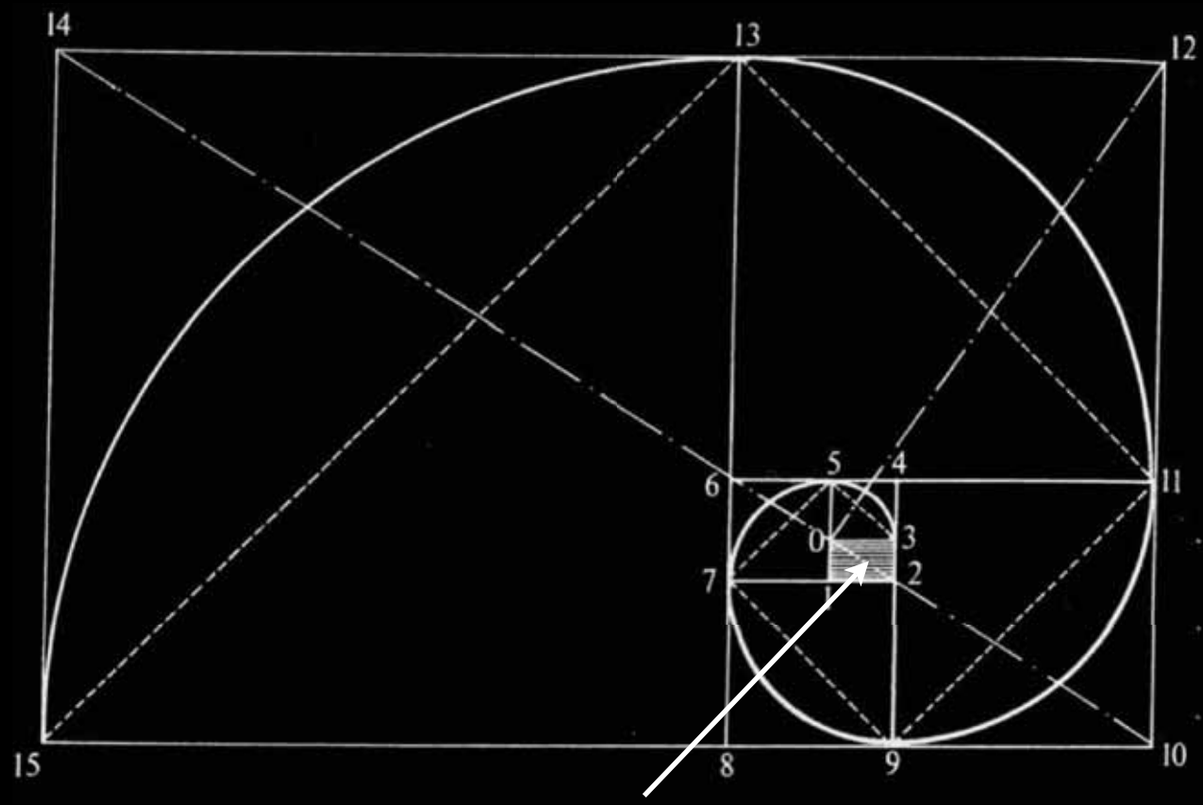
Fibonacci sequence has many other interesting mathematical properties. For example, the ratio od successive terms (larger to smaller; 1/1, 2/1, 3/2, 5/3, 8/5, 13/8....) approaches the number 1.618 (phi). This ratio is known as the Golden Ratio.

C. Cramez, Switzerland
ccramez@compuserve.com

Fibonacci's law

(Principle of Maximum Room)





"The eye of God" *T. Ferris, 1992*

The architecture of Nautillus' 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 Rations, 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").

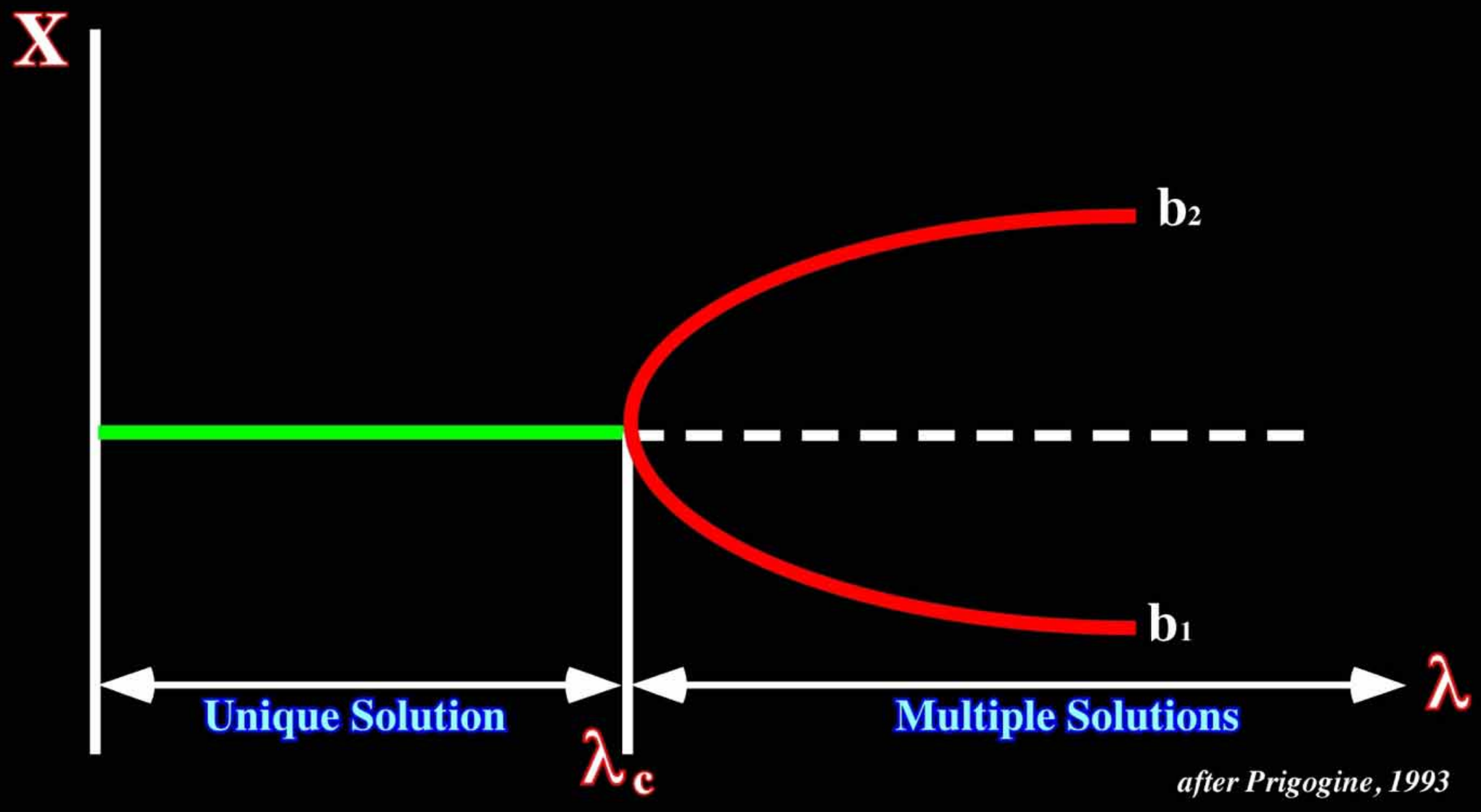
C. Cramez, Switzerland
ccramez@compuserve.com

Determinism & Probabilism

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

C. Cramez, Switzerland
ccramez@compuserve.com

Bifurcation Points



Concentration X is a function of the parameter ∂, which measures the distance from equilibrium. At the bifurcation point, the thermodynamic branch becomes unstable, and two new solutions b1 and b2 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).

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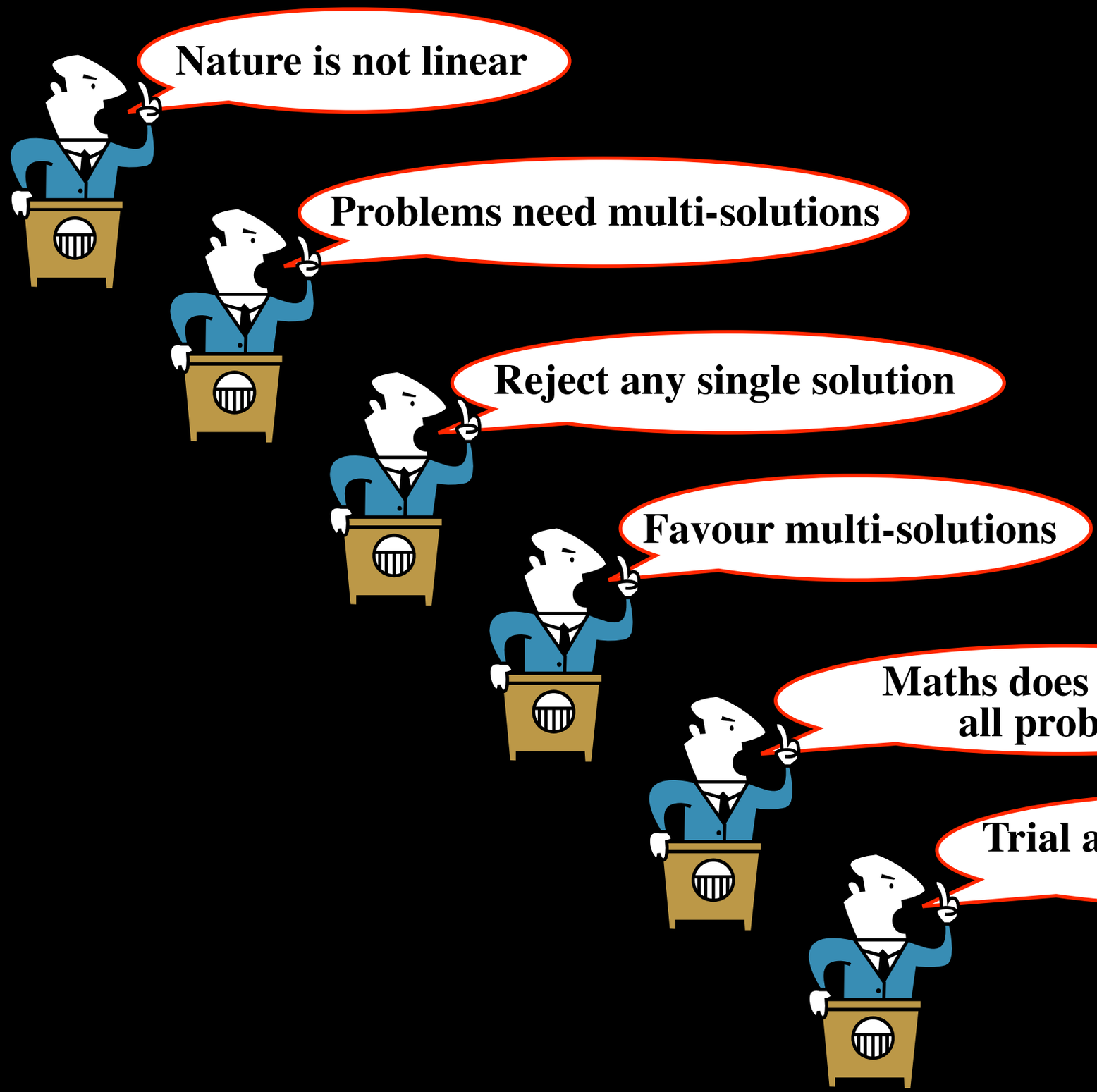


C. Cramez, Switzerland
ccramez@compuserve.com

Finally

Do not hide errors

but

try to not repeat them

C. Cramez, Switzerland
ccramez@compuserve.com

Symmetry

(Central Limit Theorem)

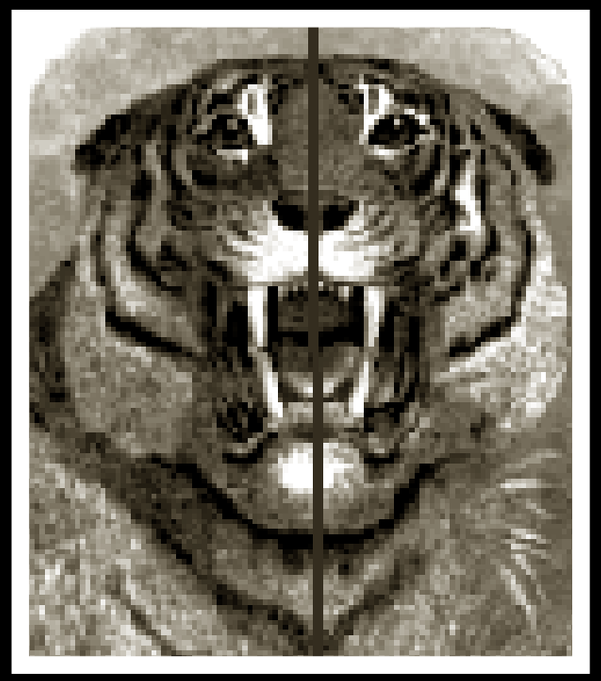
Symmetry is a major characteristic of Nature.

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

C. Cramez, Switzerland
ccramez@compuserve.com

Symmetry

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

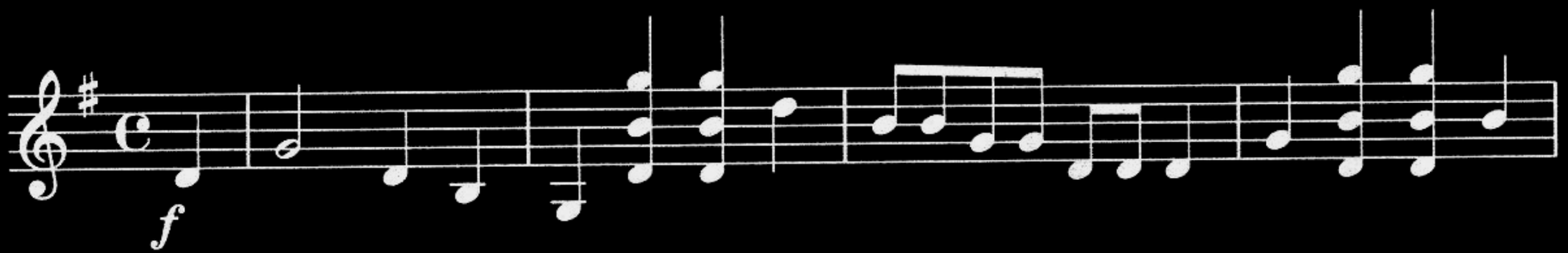


Symmetry exists all around us and many people see it as being a thing of beauty.

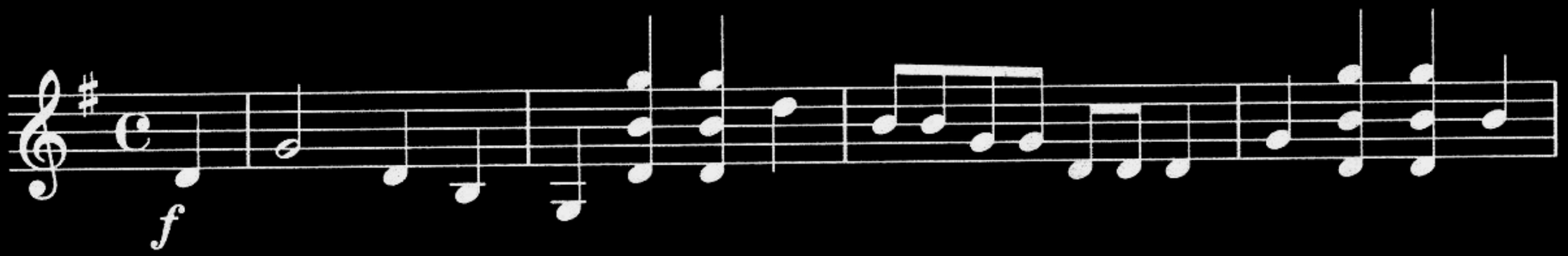
C. Cramez, Switzerland
ccramez@compuserve.com

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 Kochel 609, but Alfred Einstein put it in the *Anhang*, or appendix, of the doubtful pieces: Anh 284dd (P. Atkins, 2003).

C. Cramez, Switzerland
ccramez@compuserve.com

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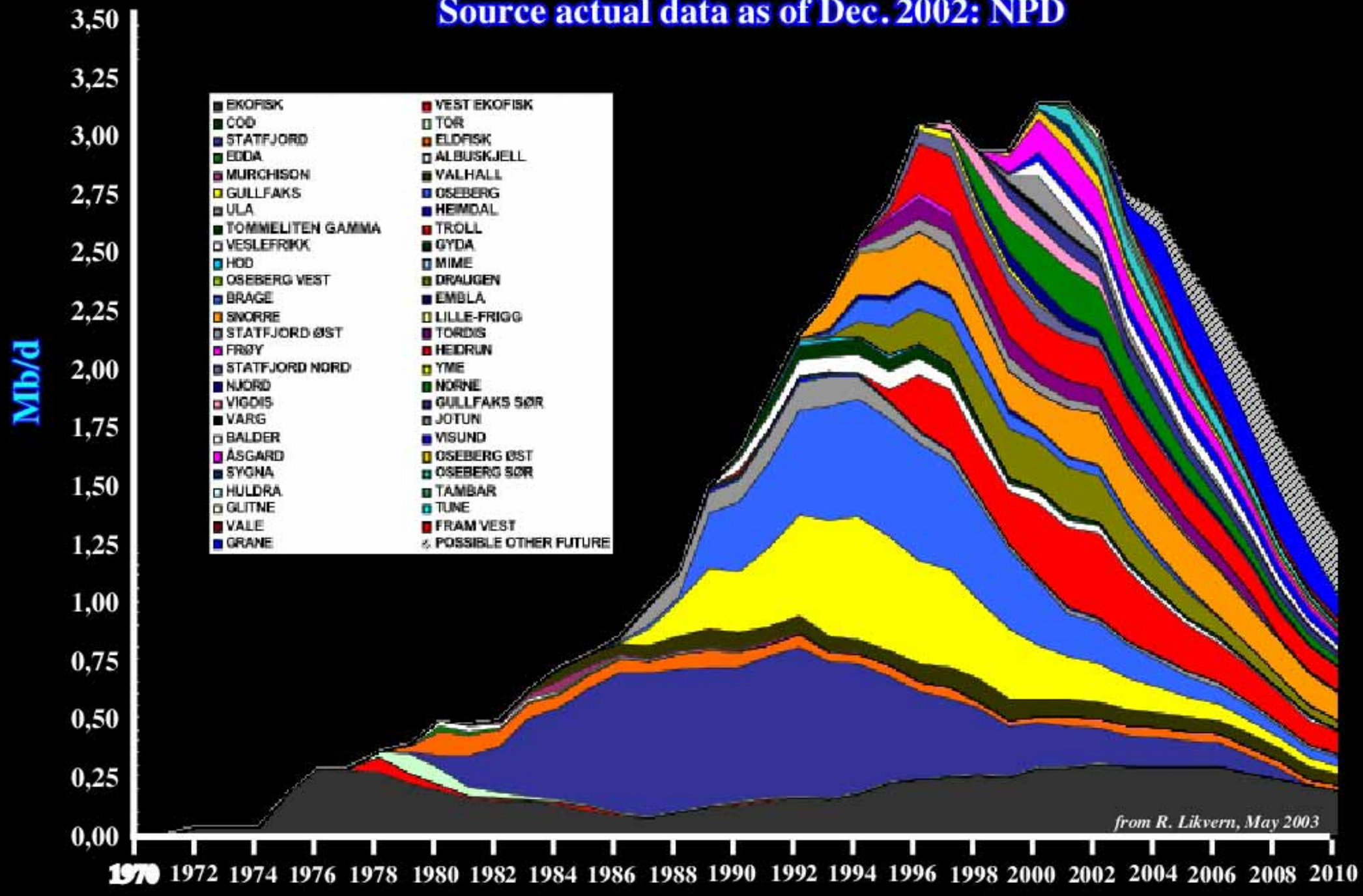
Symmetry

Actual and Forecast Oil Production From NCS

Source actual data as of Dec. 2002: NPD



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ccramez@compuserve.com

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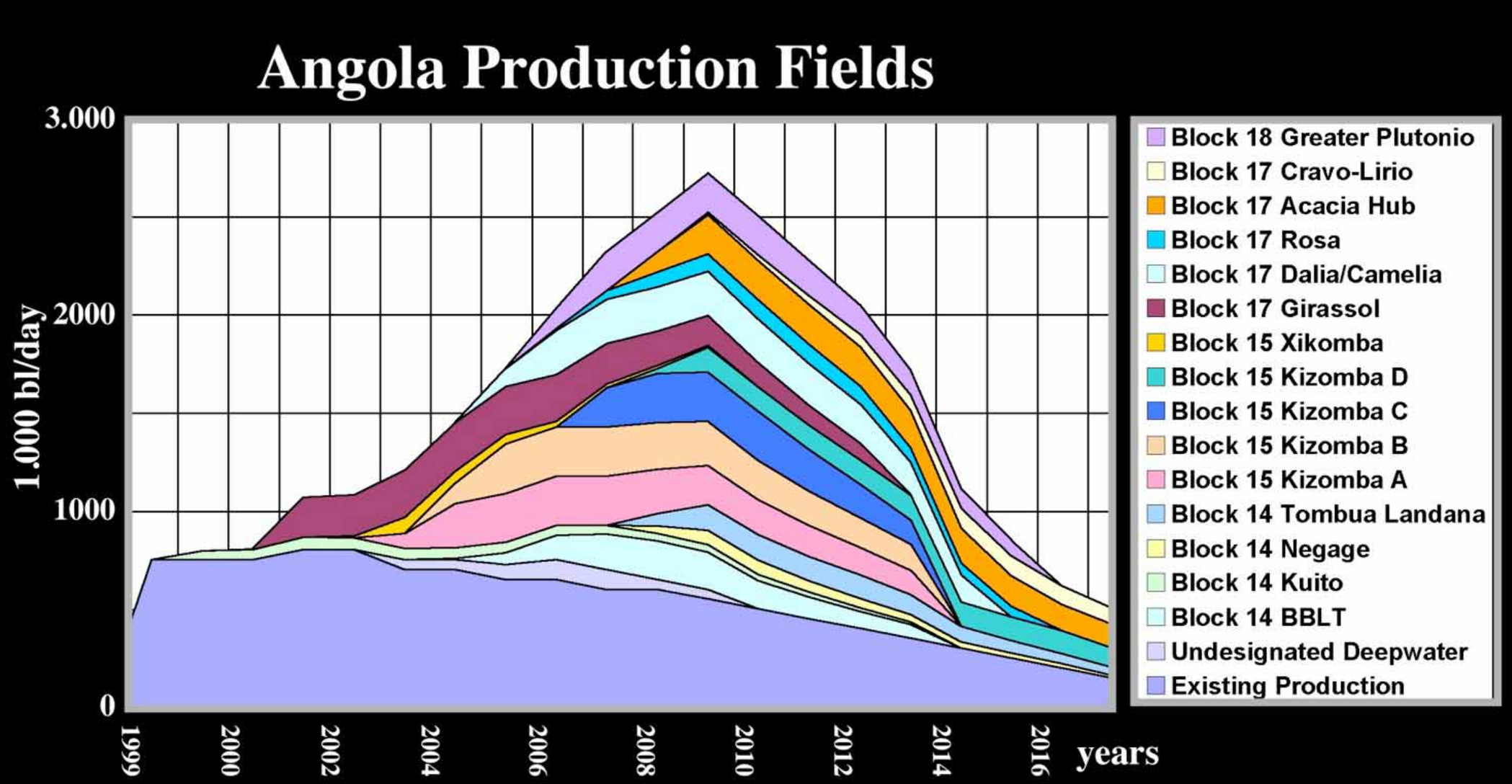
Central Limit Theorem

(Large numbers)

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



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

C. Cramez, Switzerland
ccramez@compuserve.com

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C. Cramez, Switzerland
ccramez@compuserve.com