Controversy-Based Earthscience

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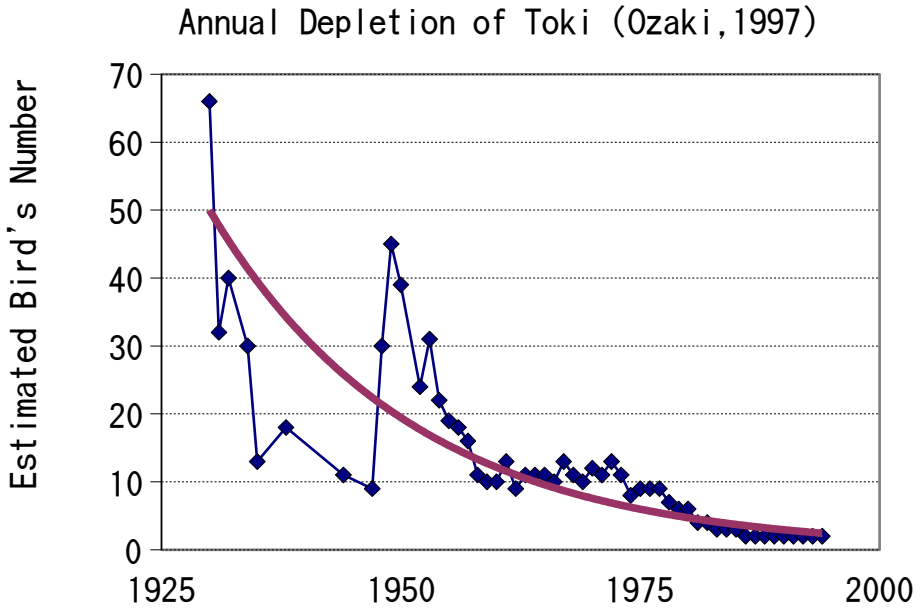
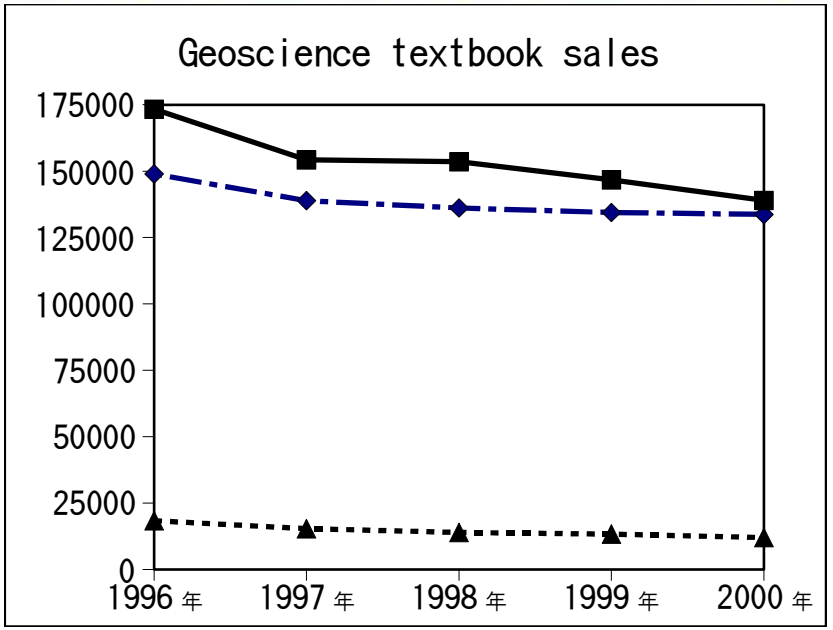
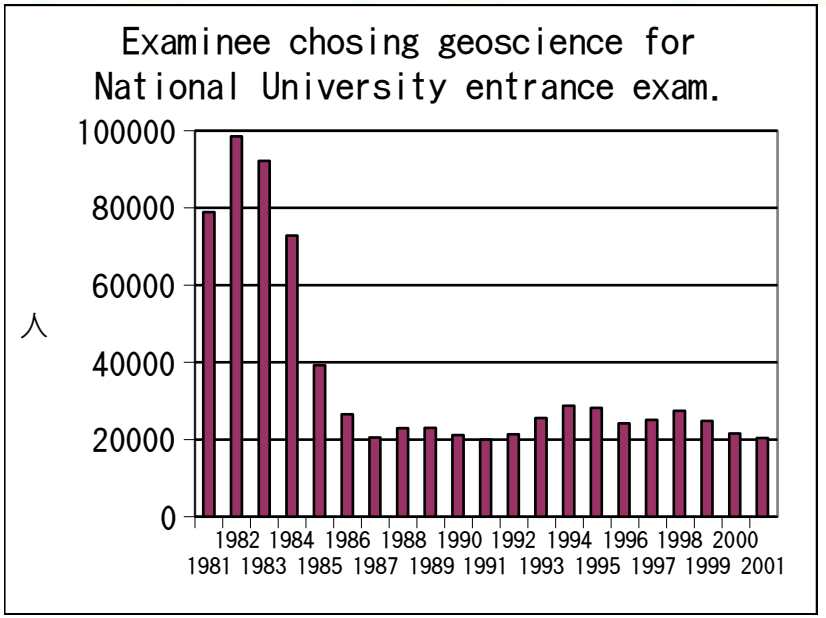
Background 1

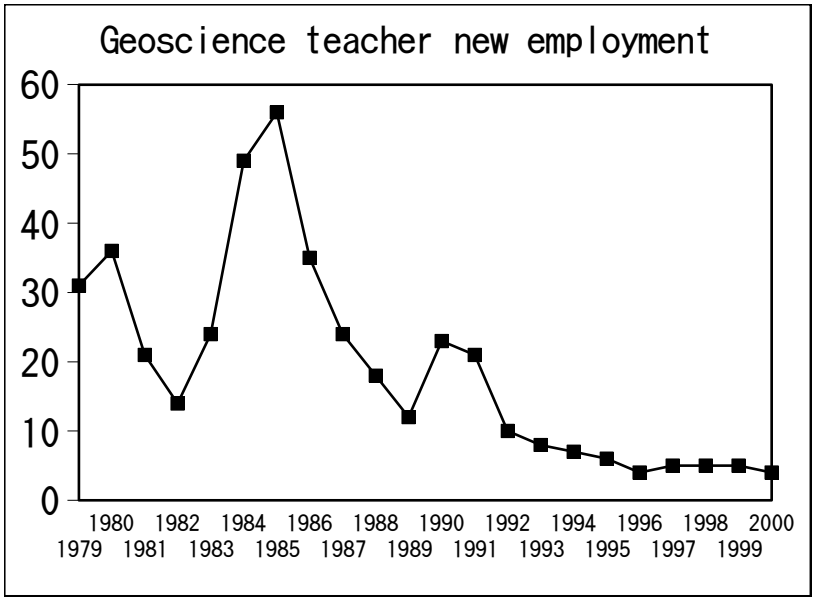
* “Nipponia Nippon 'Toki' ” already extinct in 2003.
* Index shows Earthscience education in Japan is on the road to extinction.
* Earthscience is an endangered subject at K-12 in Japan.



Index shows an 'ExtinctionVortex'







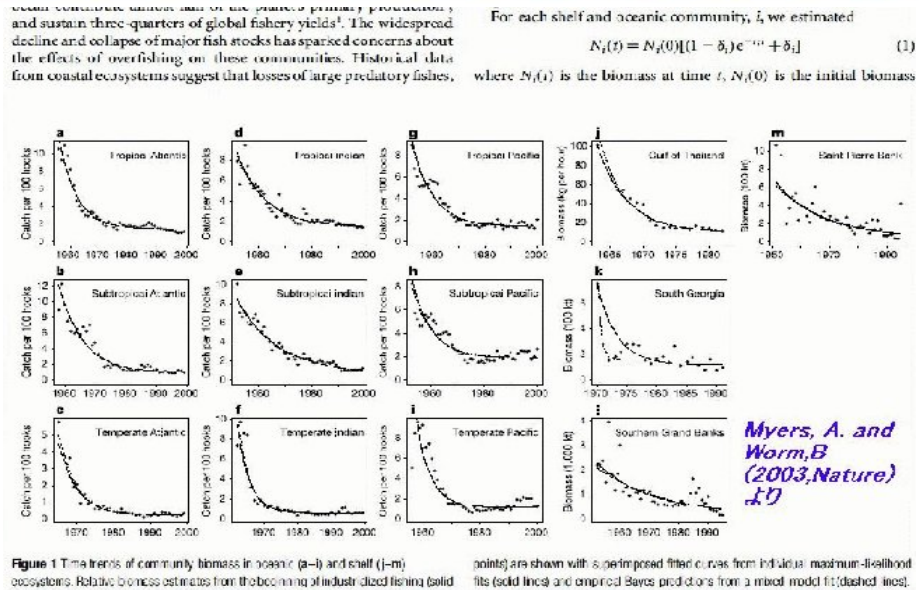
A positive feedback loop like a deflation, Okamoto 2003);

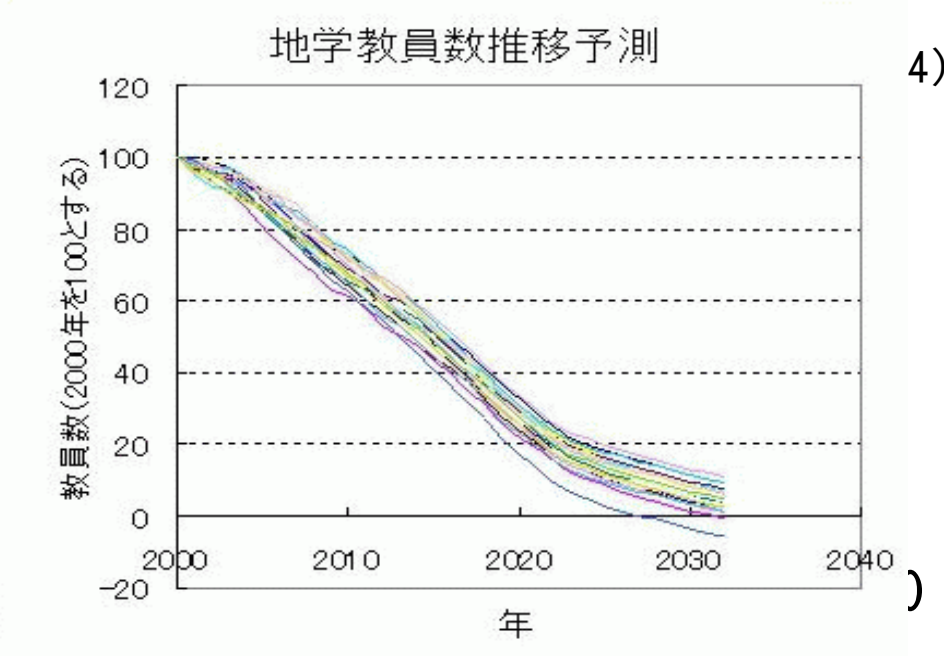
Decrease of Geoscience classes

Teachers → ***Entr. exams to Univ.***

Gambler's ruin, Raup 1993

An estimation of ESE activity





4)

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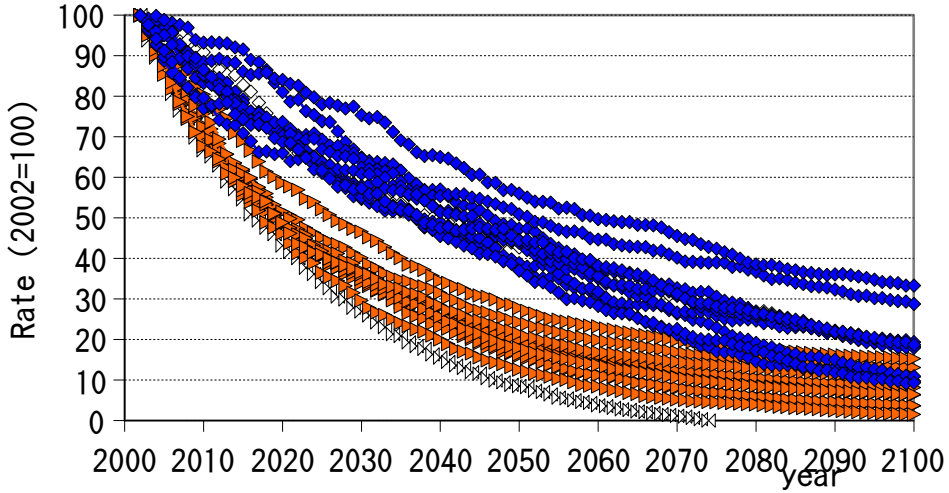
Decrease of Indexes (MonteCalro simulation)
Blue: High school class Red: Textbook sales



A 'Monte Carlo' Simulation

<Assumptions>

*** 'Exponential depletion'**

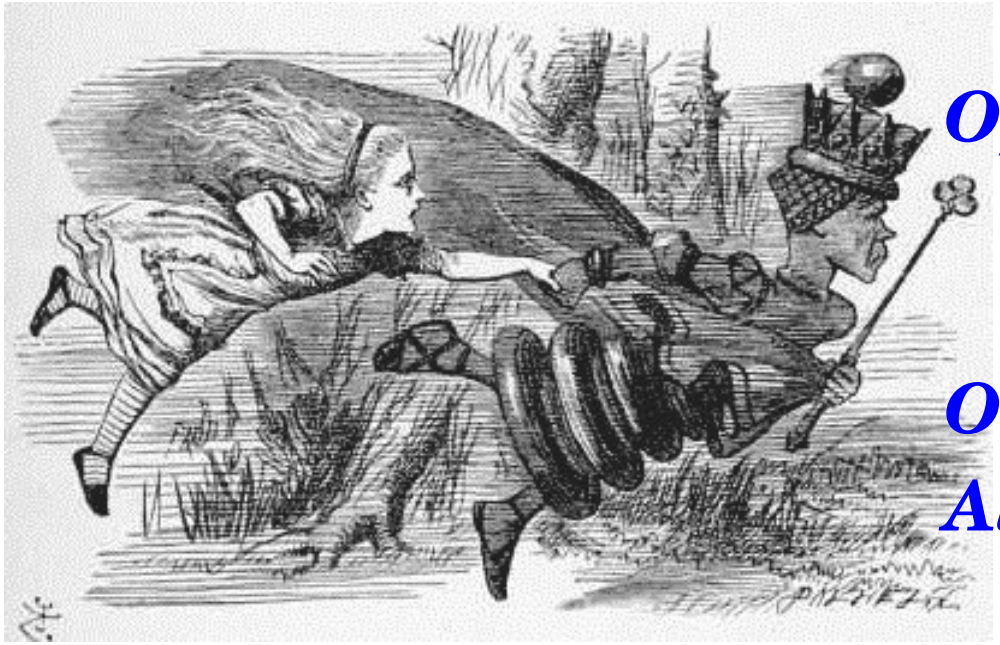
*** Initial decrease (1990-2000)**

(by M.Shibayama,2003 pers.comm)

*** 5% random fluctuation**

Background 2

"Red Queen Hypothesis"; All other science educators are running faster as they can.
"Population biology" suggests the lack of activity or diversity is the sign to extinction.



Of course a lots of efforts are tried but the trend does not change---.
Our struggle still continues, ---.
Alice! Where are you going to ---

Background 3

*** Students loose their curiosity, while rapid developments of science and technology.**

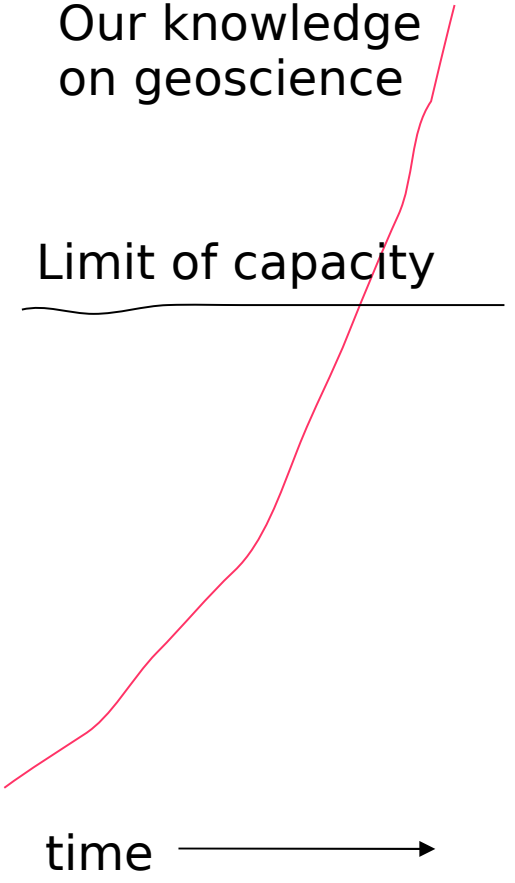
--> Inspire student!

*** The amount of knowledge will increase but our time is limited.**

--> Focus on topics!

*** What the uniqueness of earth science from the other sciences.**

--> New concepts for earthscience education!



What to do ----- Our Solution!

Traditional(20^{th}) versus Our method(21^{th})

1. Gradualism	Catastrophism
2. Deterministic	Stochastic
3. Reductionism	Complexity science
4. Rigorous & Ordered	Robust & Random
5. Linear	Non-linear
7. Pessimistic	Optimistic
8. Physics & Chemistry	Geoscience & Biology
9. Pure	Diversity
10. Formula	Games and models
11. Monopoly	Open-source

Appendix: our school's current classes;

10th Integrated Science

Physics+Chemistry+Biology+Earthscience

1h 1h 1h 1h

total=4 hours/week (for All students)

11th Chose two subjects from (P,C,B,E)

2h+2h=4 hours/week

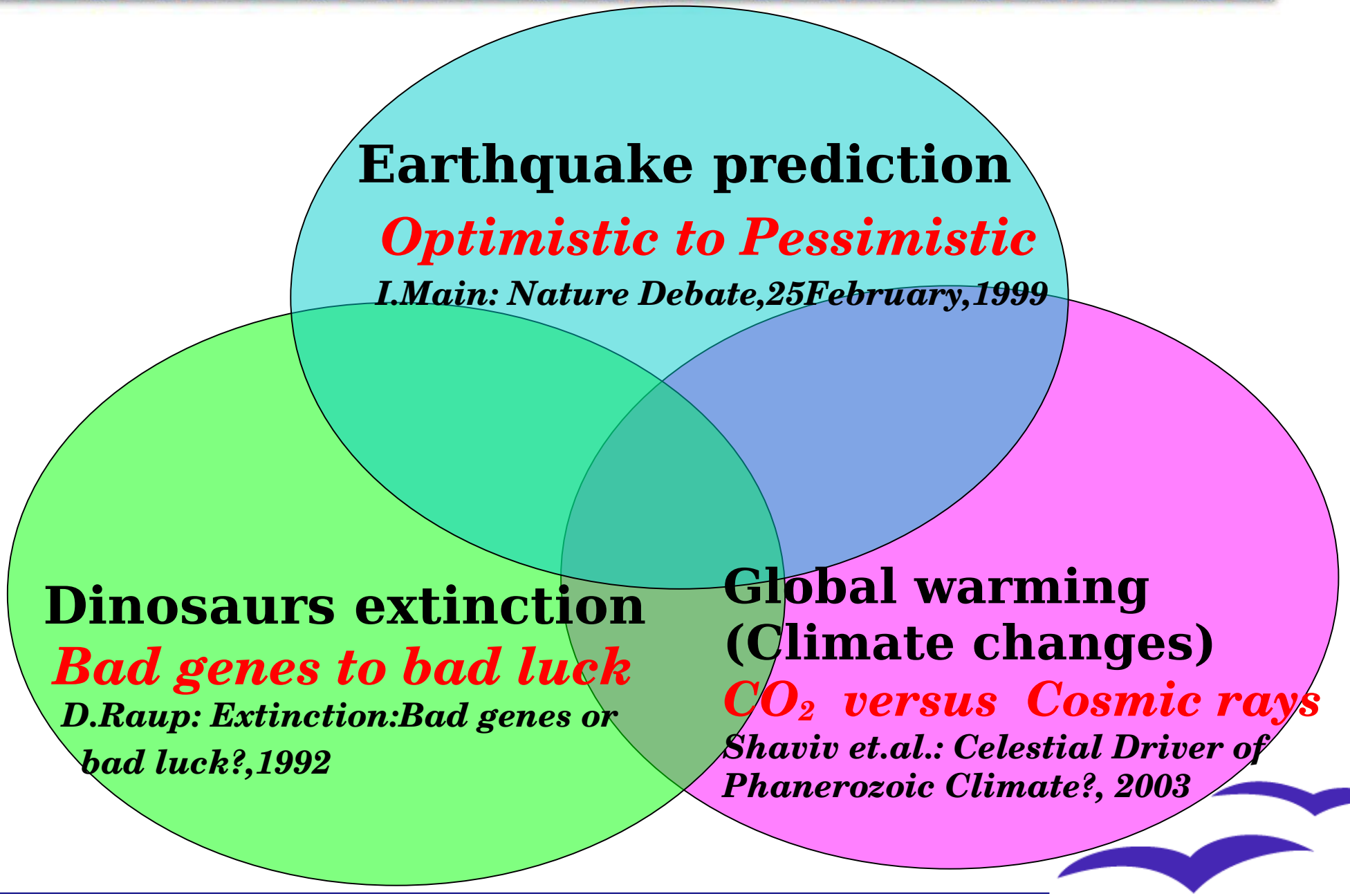
*** About 1/4 students chose ES**

12th Chose from(P,C,B,E)

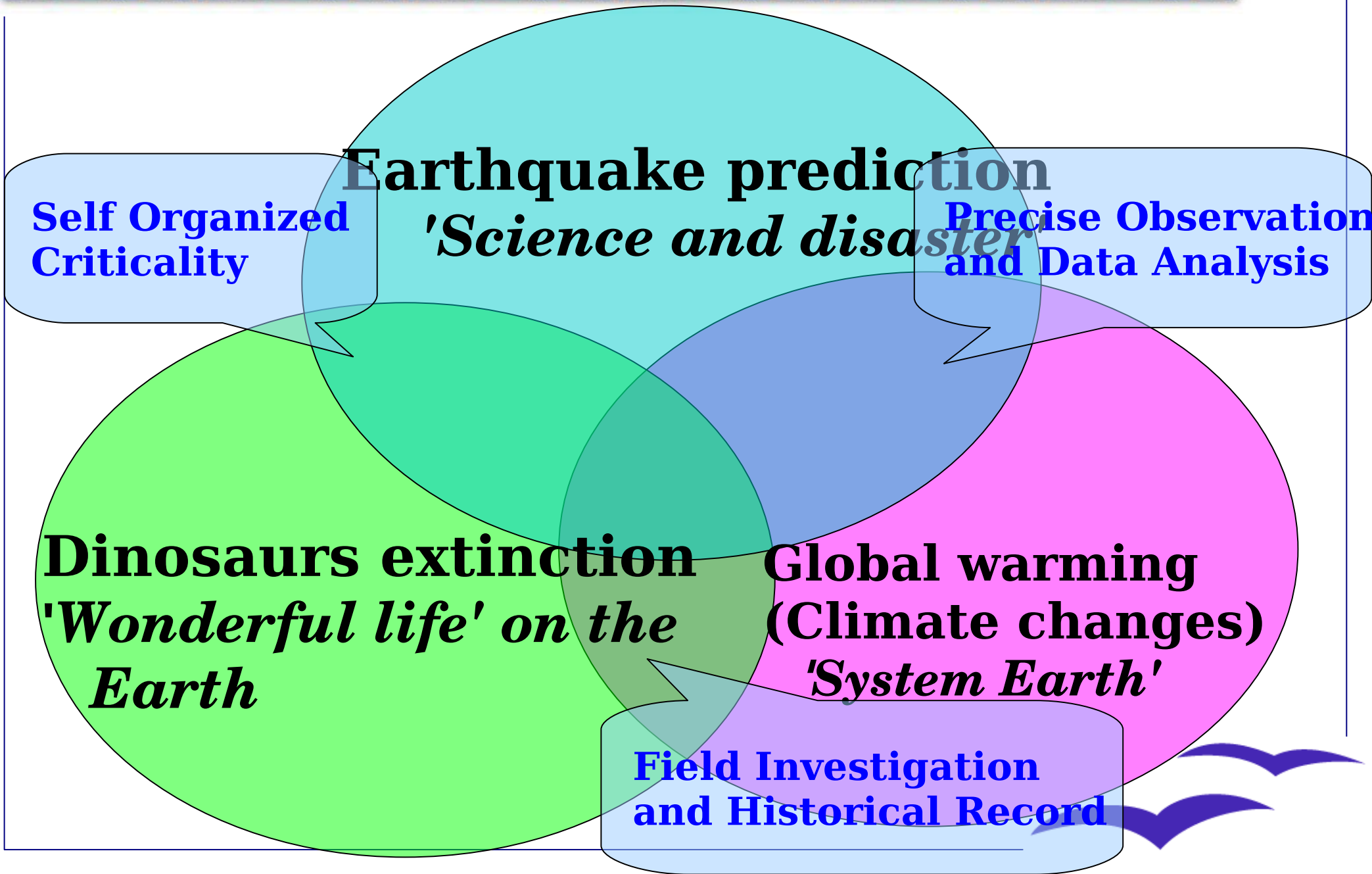
0h,3h,3h+3h(6h)/week

*** depend on their entr. exam. or Univ.**

Themes we focus on:



Concepts of our themes;



Strategy and logistics;

1. Gathering the facts and observations from the scientific magazines, books and webs.
   ---> employing the original papers.
2. Both debater's insistences are summarized and simplified for high school students.
3. Considering or modelling process is focused on as a scientific method.
4. Historical advances and researchers topics or even gossips are also highlighted.
5. Numerical or analogue modellings are used as explaining tools.

-->analogue modellings; see my poster!

Theme 1; 'Earthquake prediction'

In Japan, the people still strongly seeks the validity of short term earthquake prediction.

So, many web sites by armatures are settled and activated.

But all are empirical and there is no scientific basis, so it is like a “Omikuji” from a “Shinto Shrine”.

The short period (hours to days) prediction strategy was denied by the seismologists *(Nature debate,1999)*.

However, the mid to long-range prediction is now still discussing.

Earthquake predictor=Fortune-teller??

Psychological bias for random events

Earthquake prediction: Resources

Nature Debate(25 February 1999) on the Web

”Is the reliable prediction of individual earthquakes a realistic scientific goal?”

Chair: IAN MAIN

Discussion: *Max Wyss*, *Christopher Scholz* *Per Bak*, *Andrew Michael*, *Robert Geller etc.*

1) Pessimistic view for 'short term' empirical observation-based prediction reserch

2) Debate on “self organized criticality”

Earthquake prediction: examples 1

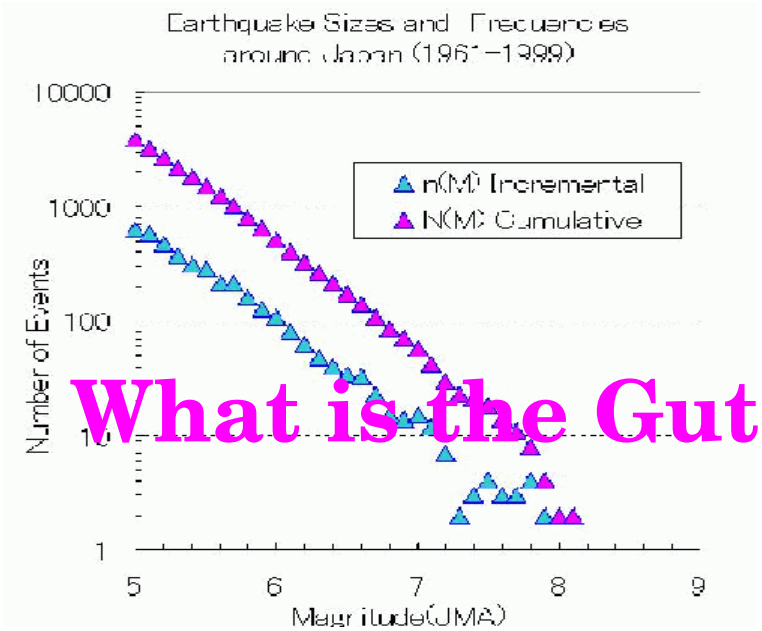


Fig.1 A lattice paper and pencils
(Left shows hit, right shows blank).

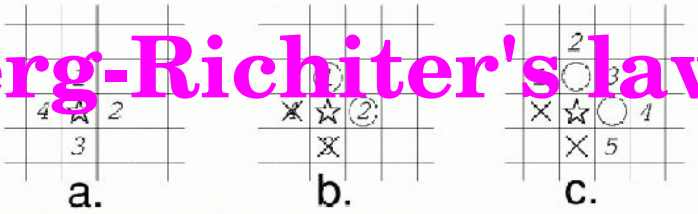
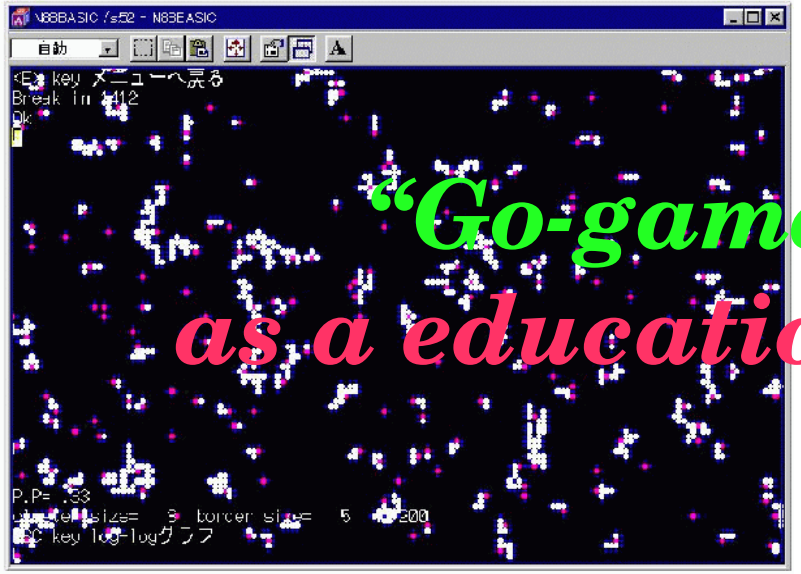
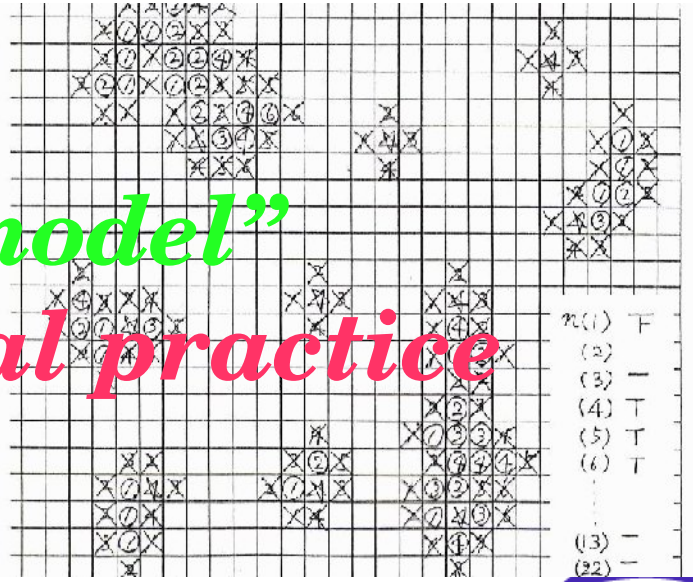


Fig.2: Rules of Go-game model.

What is the Gutenberg-Richiter's law?





"Go-game model"

as a educational practice

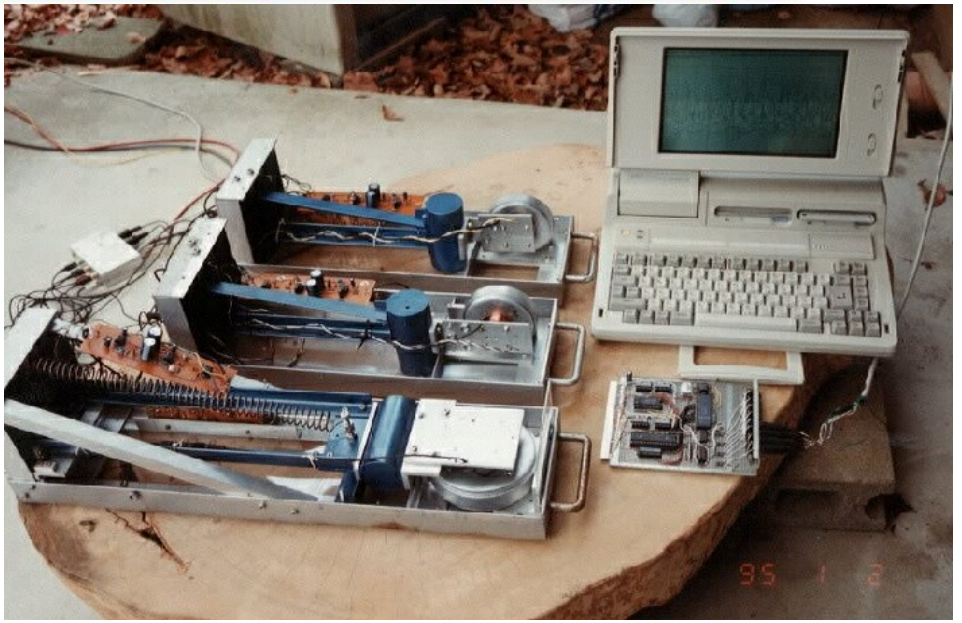
Earthquake prediction: examples 2

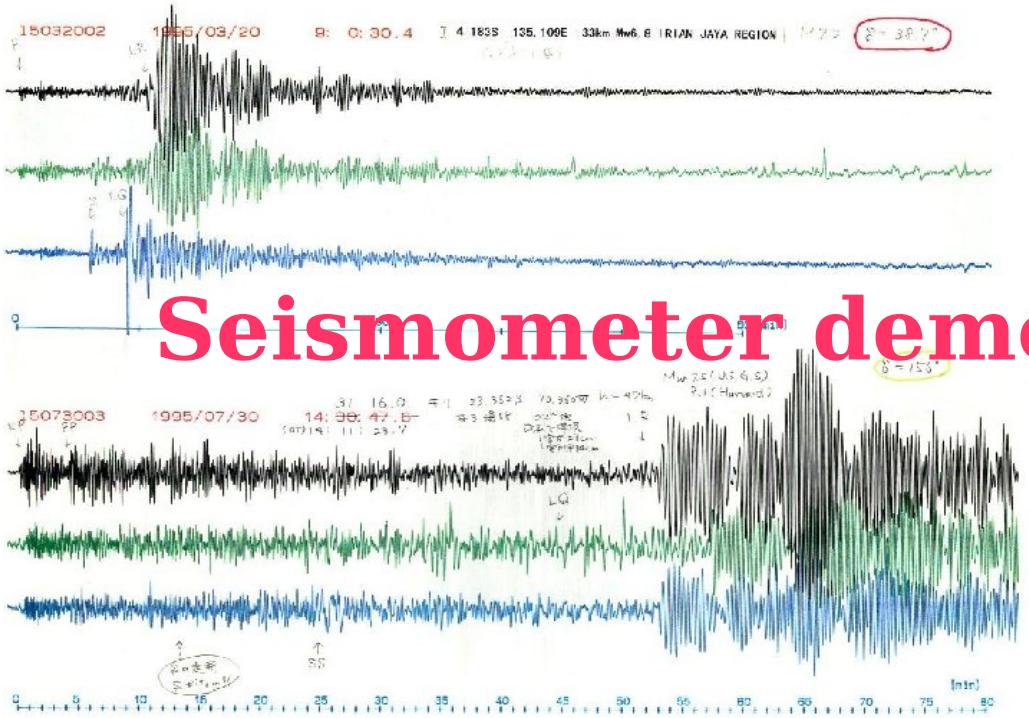
4.Some examples of Experiment (Part 1): Regular Thrust Faults

Earthquake prediction: examples 3

My hand-made seismometer

Moving-coil sensor + PC-based data logger and seismogram-----





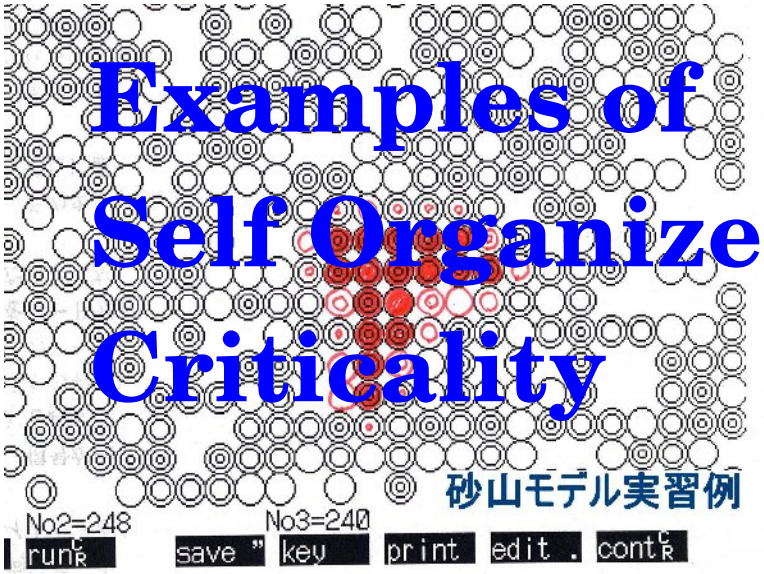
Seismometer demonstration!

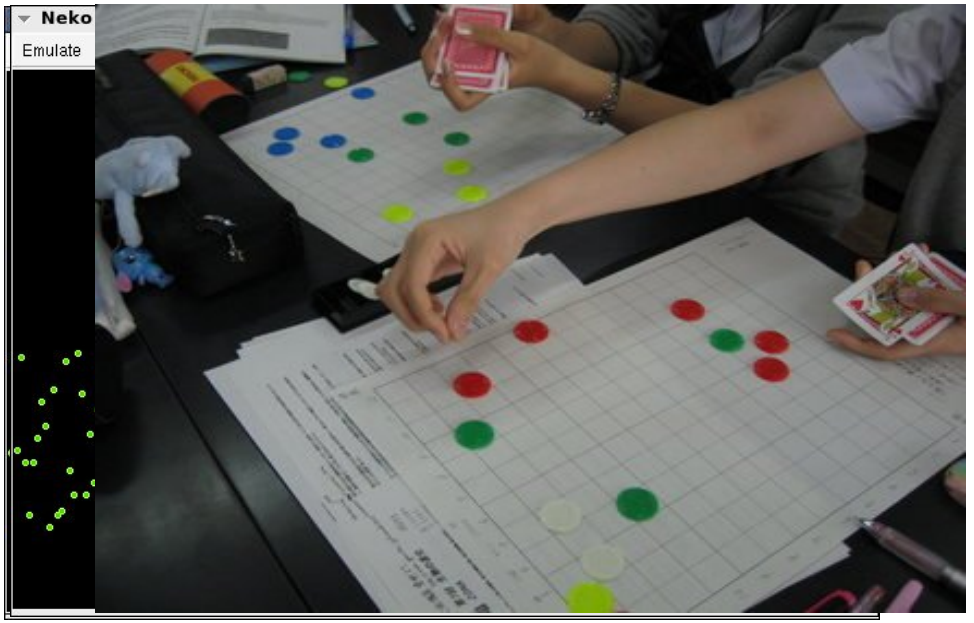
Per Bak's “Self Organized Criticality”(1989)

1. Gutenberg-Richter's law: Self organized Criticality(SOC) shows that earthquake size distribution is the most important example of natural SOC phenomena.
2. A System sized catastrophe will occur at a quite low probability but will be a fate unavoidable.
3. No tuning is necessary for evolutional system such as earthquakes, biological species, even social or economic activities.
4. So we should establish our resolution to our future as a discipline.

Sand-pile, Punctuated equilibrium Simulations

(*Per Bak et.al,1989,1993)*





'Sandpile model'
-->earthquakes

'Punctuated equilibrium'
(Gould, Bak)
--> Evolution of species

A small perturbation might cause an extinction or a catastrophe.

Through prediction debate:

1. Is an earthquake deterministic or stochastic?
2. More observations expose more facts?
3. Psychological bias for natural 'random?' events such as earthquakes or disasters.
4. Does science predict future completely?
   -->But we should exclude some skepticism against science.
6. Interpretation of noisy and sparse data.
7. Observation and modelling collaboration will only solve this problem.
8. A simple rule produces a complex result.

Theme 2; Dinosaurs extinction

The Classi
started w
iridium(1
The debate
buried cr
1991.
However, t **t**
(2002) ki
sediment
Also, the sa
employin
'Nemesis

Smoking gun? 'Nemesis' and 'Shiva'

- **The great Chicxulub debate on the Web: "Does the Impact pre-date 0.3 my?" around K/T boundary sediments in NE Mexico.**
  Gerta Keller vs. Jan Smit
  http:www.geolsoc.org.uk/chicxulub

'Nemesis' is a virtual planet employed for the asteroid impact theory.

'Shiva' is a goddess symbolizing the volcanic theory.

Nemesis versus Shiva!

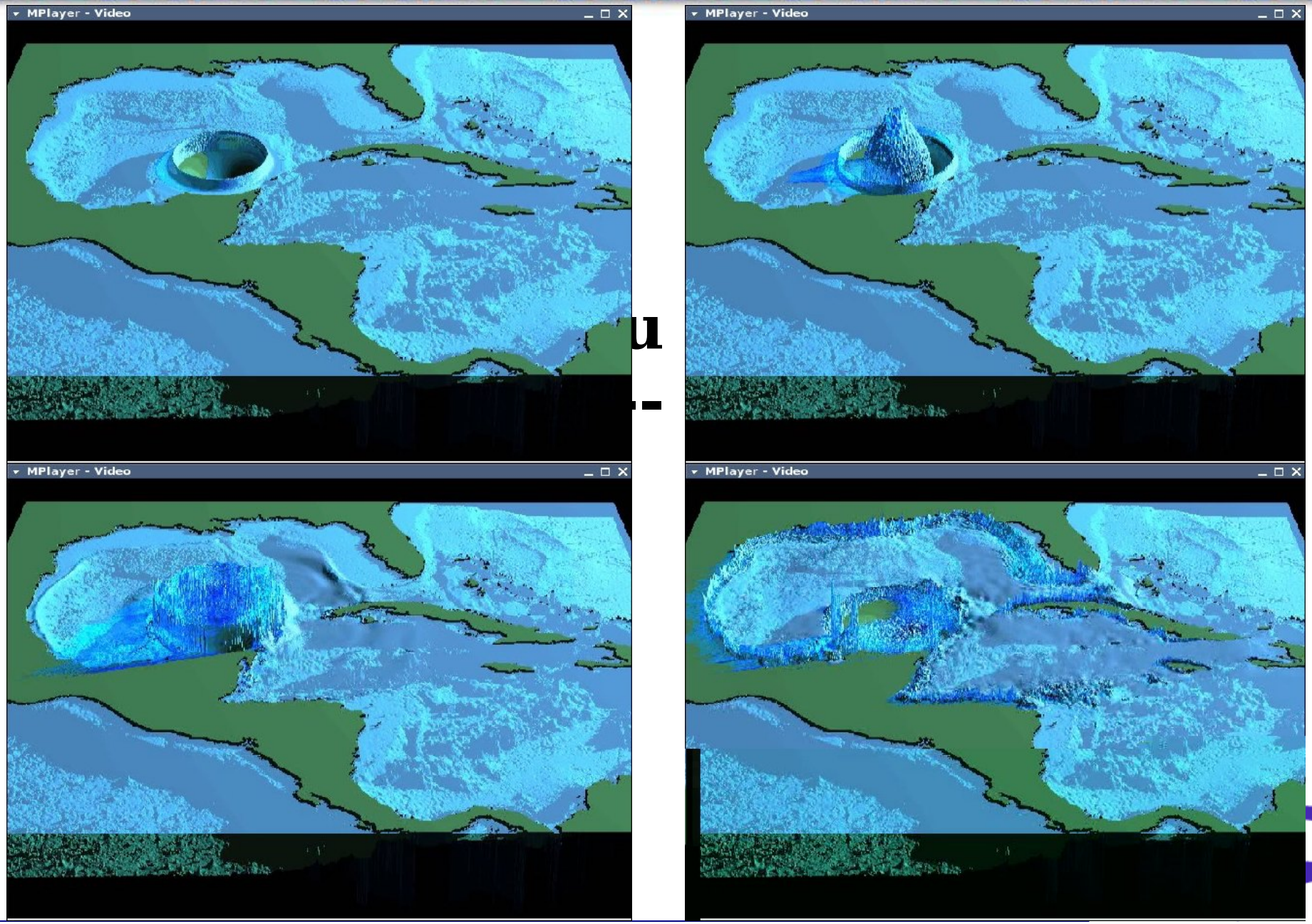
http://homepage.mac.com/cparada/GML/Nemesis.html

http://www.lotussculpture.com/

K-T impact tsunami: an numerical simulation

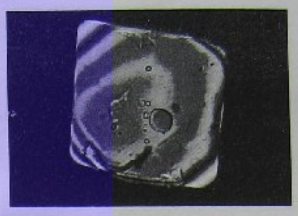
* Tsunami simulation after the KT impact
* Simplified tsunami equation
* Mexico gulf area contemporary Bathymetry
  -> No scientific basis!
* Gaussian functional sea-surface uplift after deep impact
* A C-program on linux OS run a calculation for 10-hours' reproduction.
* A Free-ware tool 'Povray 3.5' on Linux is used for realistic three dimensional renderings.
* Tsunamis reached the shore line of the gulf of Mexico several hours after the impact.

K-T Tsunami simulation



A printed synopsis for 11th

FIGURE 3 Luis and Walter Alvarez studying the K–T section at Gubbio, Italy. Walter Alvarez has his finger on the boundary. [Photo courtesy of University of California Lawrence Berkeley National Laboratory.]



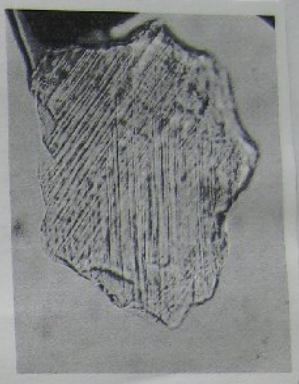


FIGURE 12 (Top) Unshocked quartz from an explosive volcanic rock in the Jemez Mountains, New Mexico. Note the absence of shock planes. (Right) Shocked quartz from the K–T boundary in the Raton Basin, Colorado, showing two sets of shock planes. [Photo courtesy of Glenn Izett.[27]]

FIGURE 13 The K–T boundary in the Raton Basin. [Photo courtesy of Glenn Izett.]

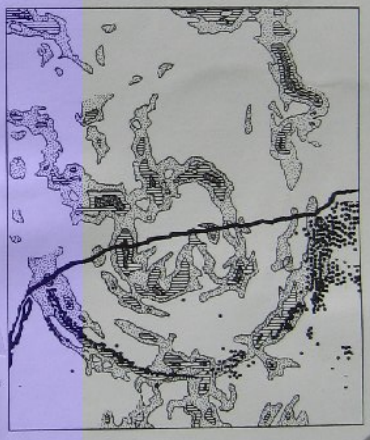


FIGURE 14 The cenote ring at Chicxulub (dark circles) superimposed on the gravity anomaly map. Note how the cenotes to the middle and left trace out part of a nearly perfect circle. The solid line is the current coastline of Yucatán. [Photo courtesy of Alan Hildebrand and Geological Survey of Canada. For this and other images, see web page at http://dsaing.uqac.uquebec.ca/~mhiggins/MIAC/chicxulub.htm.]

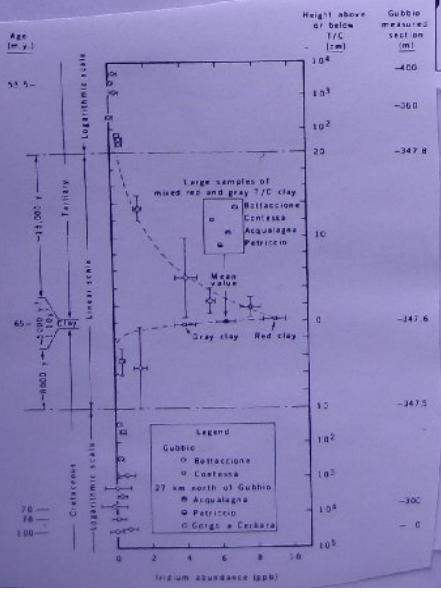


Fig. 5. Iridium abundances per unit weight of 2*N* HNO_3 acid-insoluble residues from Italian limestones near the Tertiary - Cretaceous boundary. Error bars on abundances are the standard deviations in counting radioactivity. Error bars on stratigraphic position indicate the stratigraphic thickness of the sample. The dashed line above the boundary is an "eyeball fit" exponential with a half-height of 4.6 cm. The dashed line below the boundary is a best fit exponential (two points) with a half-height of 0.43 cm. The filled circle and error bar are the mean and standard deviation of Ir abundances in four large samples of boundary clay from different locations.

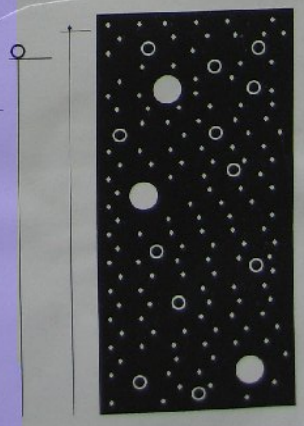


FIGURE 19 The Signor-Lipps effect. [After Michael Williams.[16]]

Through K/T debate:

1. Recognition of 'The law of Superposition'.
2. 'Gradualism' versus 'Catastrophism'
3. 'Bad genes' or 'Bad luck'?
4. Is our existence deterministic or stochastic?
   -->Gould "Wonderful life"
   ------>Carter, Dicke 'Anthropic principle'
5. Impact versus Punctuated equilibrium
6. How survive the species lived on the earth.
7. Diversity of species is a key to survive.
8. Painstaking field survey and high-tech collaboration success to make a cutting-edge.

-->If the KT impact would failed----.

Theme 3; Debate on Global Warming

Some skepticisms for global warming based on ICPP (2001) are now raising.

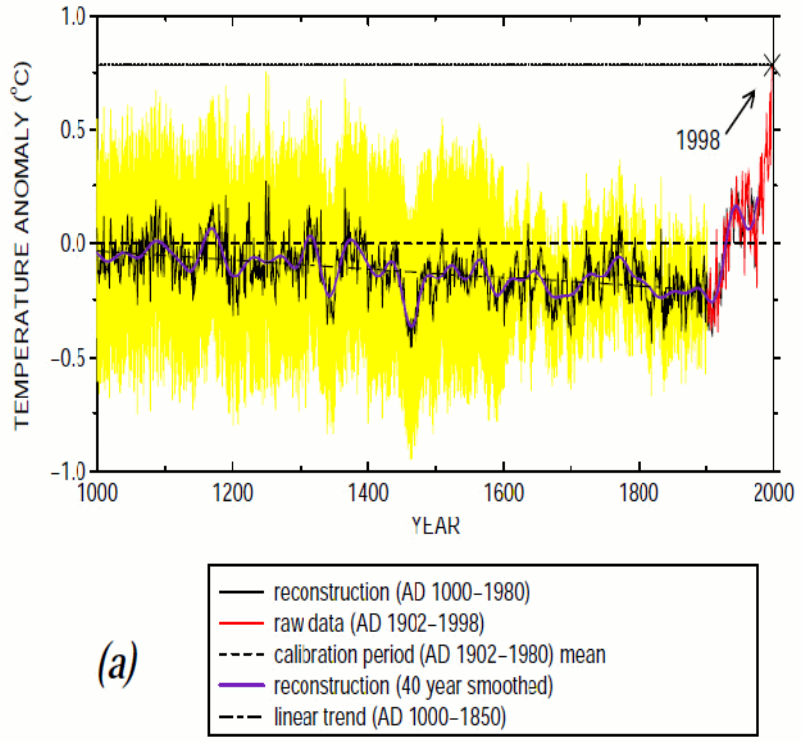
The critics say;

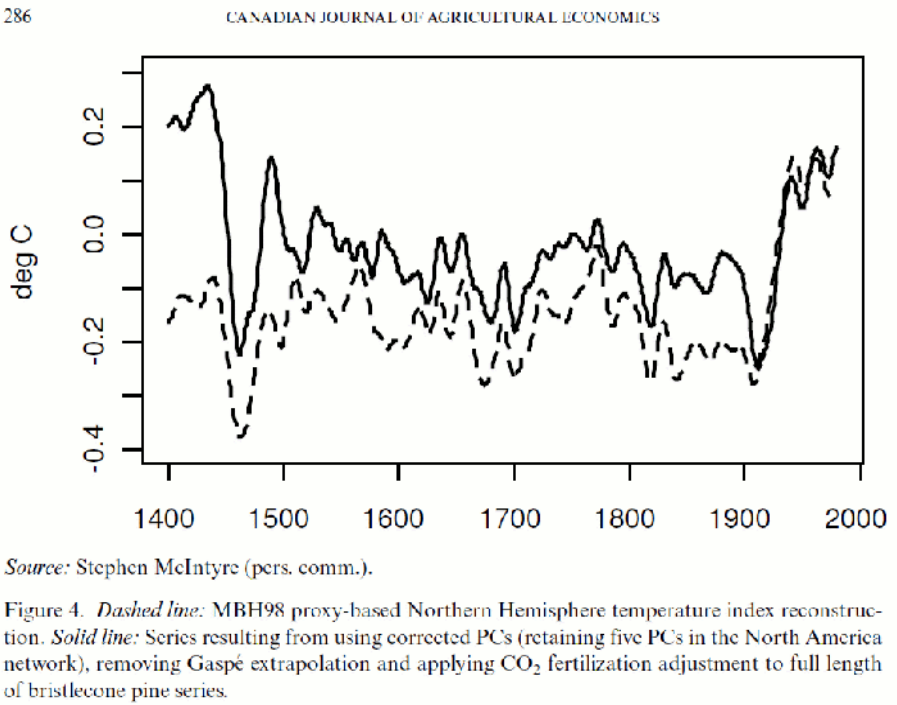
1. The warming in late 20th century is an illusion. ----- "Hockey stick debate"
by *McIntyre & McKitrick (2003)* against *Mann et.al.(1999)*

2. Climate driver is not CO_2 but celestial Cosmic Ray Flux(CRF).

by *Shaviv et.al.: Celestial Driver of Phanerozoic Climate?, 2003*

“Hockey stick debate”





Source: Stephen McIntyre (pers. comm.).

Figure 4. *Dashed line:* MBH98 proxy-based Northern Hemisphere temperature index reconstruction. *Solid line:* Series resulting from using corrected PCs (retaining five PCs in the North America network), removing Gaspé extrapolation and applying CO_2 fertilization adjustment to full length of bristlecone pine series.

Mann et. al. 1999--> IPCC,2001

Hockey stick: Yes!

McIntyre & McKitrick (2003)

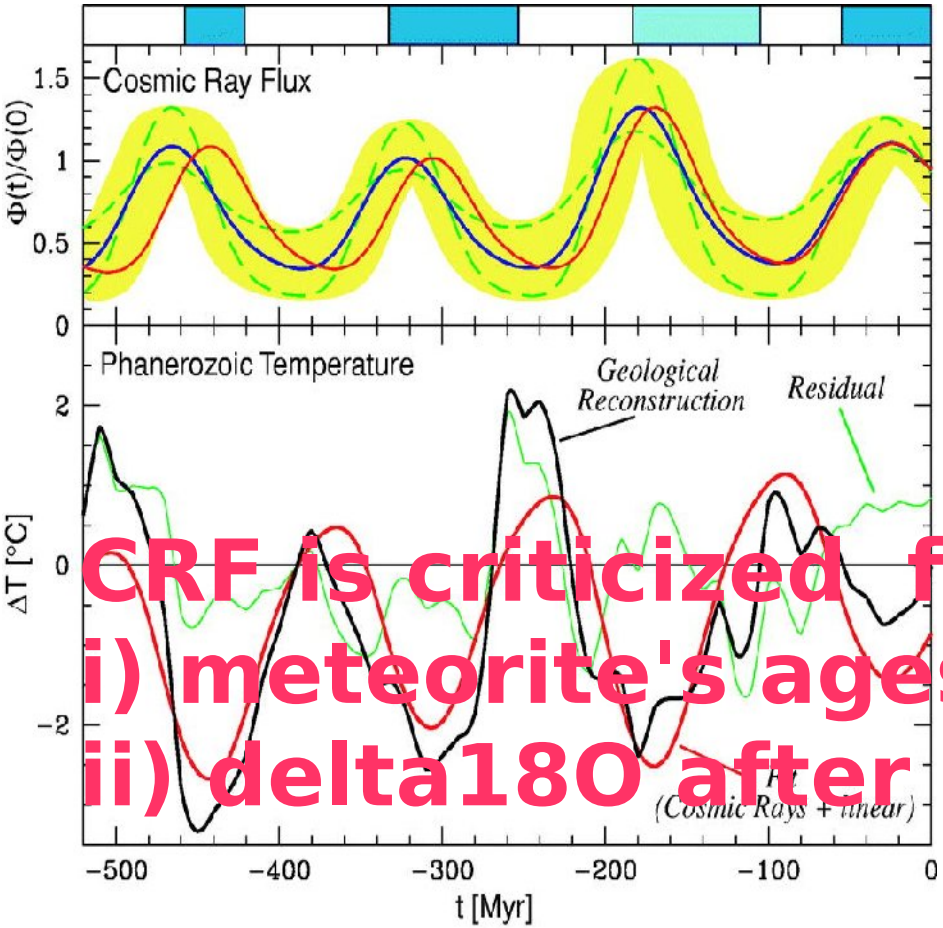
Hockey stick: No!

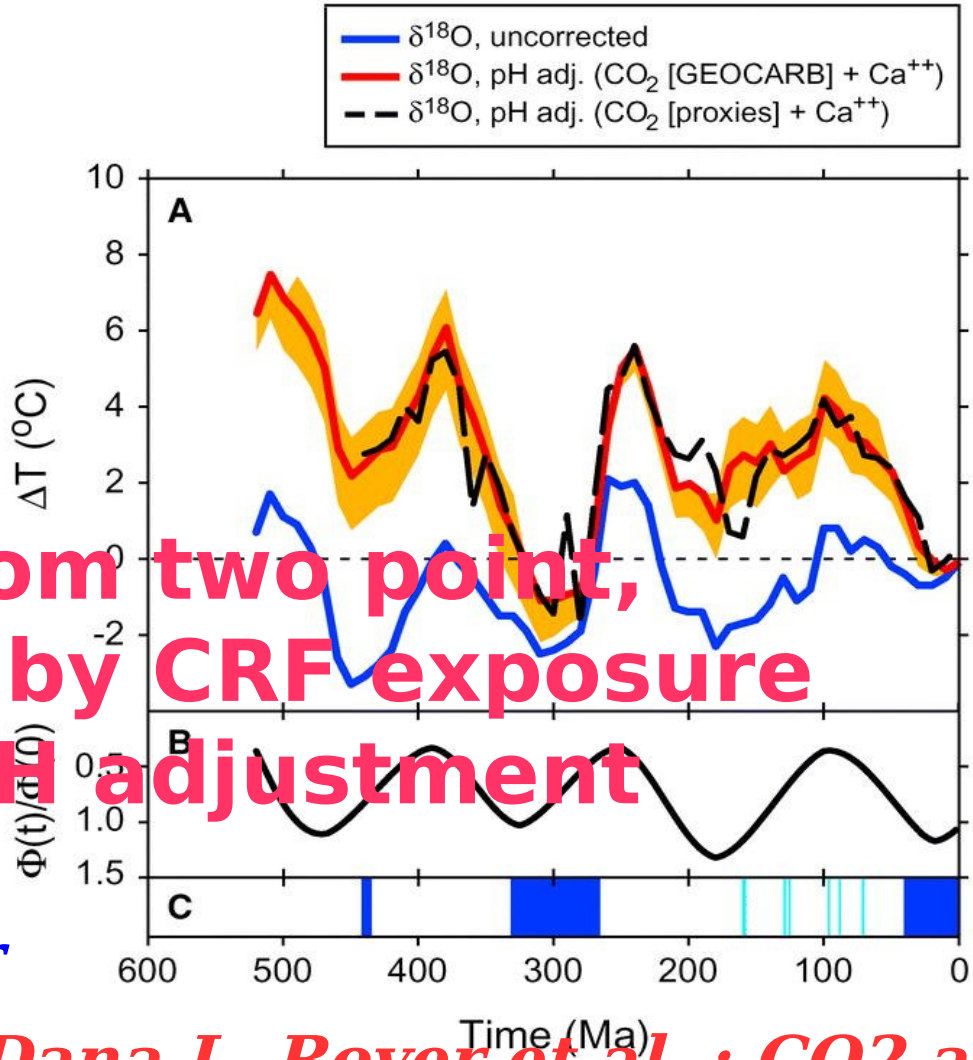
CRF or CO_2 as a climate driver?

Shaviv et.al.: Celestial Driver of Phanerozoic Climate?, 2003

Dana L. Royer et.al. : CO2 as a primary driver of Phanerozoic climate,2004

CRF or CO_2 as a climate driver?





CRF is criticized from two point,
i) meteorite's ages by CRF exposure
ii) delta18O after pH adjustment

Shaviv et.al.: Celestial Driver of Phanerozoic Climate?, 2003

Dana L. Royer et.al. : CO2 as a primary driver of Phanerozoic climate,2004

A printed synopsis related

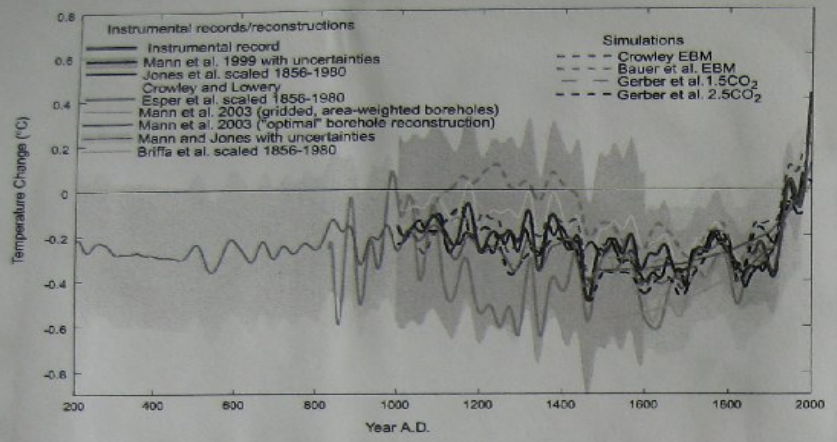
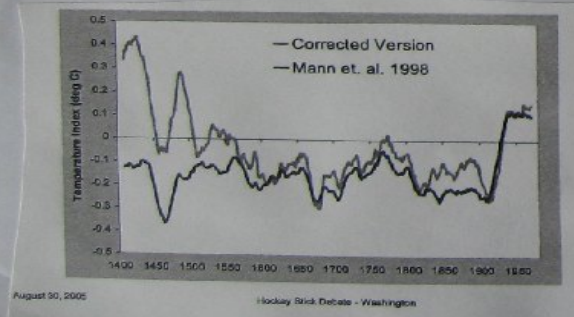


Figure 1. Comparison of proxy-based NH temperature reconstructions [*Jones et al.*, 1998; *Mann et al.*, 1999; *Crowley and Lowery*, 2000] with model simulations of NH mean temperature changes over the past millennium based on estimated radiative forcing histories [*Crowley*, 2000; *Gerber et al.*, 2002--results shown for both a 1.5°C/2*CO_2 and 2.5°C/2*CO_2 sensitivity; *Bauer et al.*, 2003). Also shown are two independent reconstructions of warm-season extratropical continental NH temperatures [*Briffa et al.*, 2001; *Esper et al.*, 2002] and an extension back through the past two thousand years based on eight long reconstructions [*Mann and Jones*, 2003]. All reconstructions have been scaled to the annual, full Northern Hemisphere mean, over an overlapping period (1856-1980), using the NH instrumental record [*Jones et al.*, 1999] for comparison, and have been smoothed on time scales of >40 years to highlight the long-term variations. The smoothed instrumental record (1856-2000) is also shown. The gray/red shading indicates estimated two-standard error uncertainties in the *Mann et al.* [1999] and *Mann and Jones* [2003] reconstructions. Also shown are reconstructions of ground surface temperatures (GST) based on appropriately areally-averaged [*Briffa and Osborn*, 2002; *Mann et al.*, 2003] continental borehole data [*Huang et al.*, 2000], and hemispheric surface air temperature trends, determined by optimal regression [*Mann et al.*, 2003] from the GST estimates. All series are shown with respect to the 1961-90 base period.



↑ IPCCが根拠とするMann et. al. の気温データ [1998, 2004]

← Mann et. al に対するMcIntyre McKitrick [2005] の批判

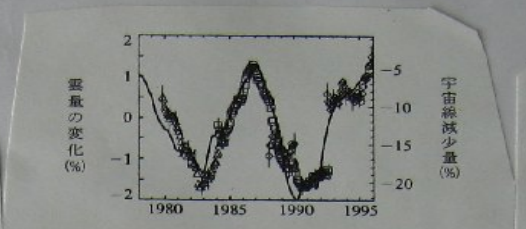


図14　宇宙線量（実線）と雲量（記号）の年変化。両者はよく似た変化をしている。（グラフは、H. Svensmark and E. Friis-Christensen, *J. Atmos. Solar-Terr. Phys.*, 59, 1225, 1997より引用）

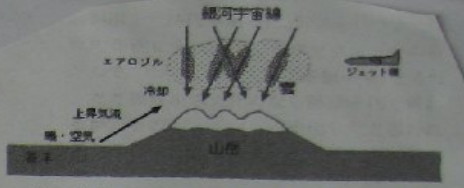


図16　水蒸気を含んだ暖かい空気は上昇し、上空で冷却される。すると水蒸気を育みきれなくなり過飽和状態となる。一方上空では、宇宙からやってきた銀河宇宙線が大気中でイオンの種を盛んに作り出している。このイオンの種が核となって水は凝結し、小さな水滴や氷の粒になると考えられる。もちろん塵も凝結核となる。これらが空に浮かんでいるのが雲である。従って宇宙線が増大すれば、理論的には雲量は増大するはずである。

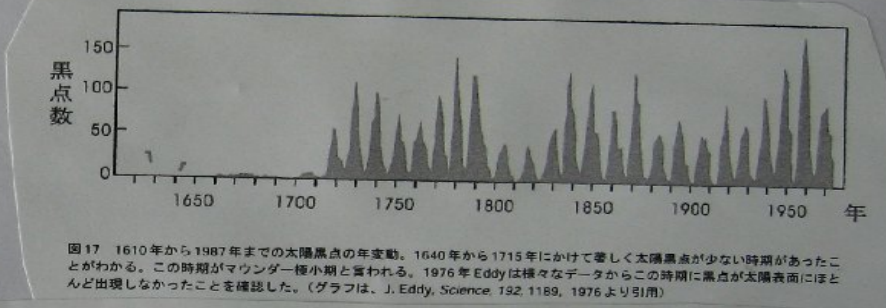


図17　1610年から1987年までの太陽黒点の年変動。1640年から1715年にかけて著しく太陽黒点が少ない時期があったことがわかる。この時期がマウンダー極小期と言われる。1976年Eddyは様々なデータからこの時期に黒点が太陽表面にほとんど出現しなかったことを確認した。（グラフは、J. Eddy, *Science*, 192, 1189, 1976より引用）

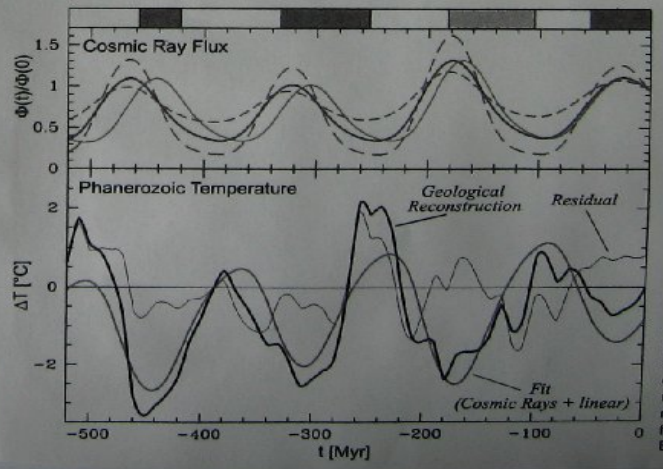


Figure 2. The cosmic ray flux (Φ) and tropical temperature anomaly (ΔT) variations over the Phanerozoic. The upper curves describe the reconstructed CRF using iron meteorite exposure age data (Shaviv, 2002b). The blue line depicts the nominal CRF, while the yellow shading delineates the allowed error range. The two dashed curves are additional CRF reconstructions that fit within the acceptable range (together with the blue line, these three curves denote the three CRF reconstructions used in the model simulations). The red curve describes the nominal CRF reconstruction after its period was fine tuned to best fit the low-latitude temperature anomaly (i.e., it is the "blue" reconstruction, after the exact CRF periodicity was fine tuned, within the CRF reconstruction error). The bottom black curve depicts the 10/50 m.y. (see Fig. 1) smoothed temperature anomaly (ΔT) from Veizer et al. (2000). The red line is the predicted ΔT_{model} for the red curve above, taking into account also the secular long-term linear contribution (term $B \times t$ in equation 1). The green line is the residual. The largest residual is at 250 m.y. B.P., where only a few measurements of $\delta^{18}O$ exist due to the dearth of fossils subsequent to the largest extinction event in Earth history. The top blue bars are as in Figure 1.

Related areas and topics:

"Huge catastrophic eruption" *by Thompson(2000)*

"Snow ball earth" *by Kirschvink(1992) & Hoffman(1998)*

"Ediacara fauna"

"Cambrian explosion"& "Burgess shale"

by Wittington et.al(1980's~), Gould "Wonderful life"(1991)

"Five Great Extinctions through history"

by Raup(1993)

"The Cretaceous Greenhouse"

"The Black sea deluge" as "Noah's flood"

by Ryan & Pitman(1998)

"The* Dansgaard–Oeschger Oscillation" *and

"The Younger Dryas Stadial"

by Dansgaard, W., et al. (1989)

A printed synopsis related

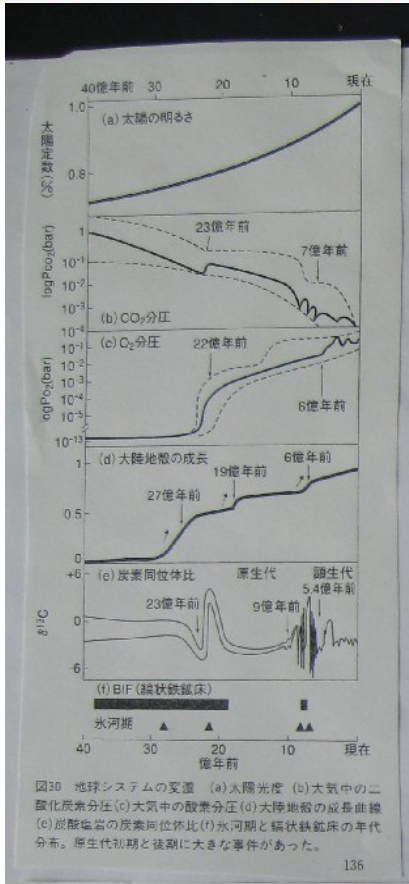


図30 地球システムの変遷 (a)太陽光度 (b)大気中の二酸化炭素分圧(c)大気中の酸素分圧(d)大陸地殻の成長曲線(e)炭酸塩岩の炭素同位体比(f)氷河期と縞状鉄鉱床の年代分布。原生代初期と後期に大きな事件があった。

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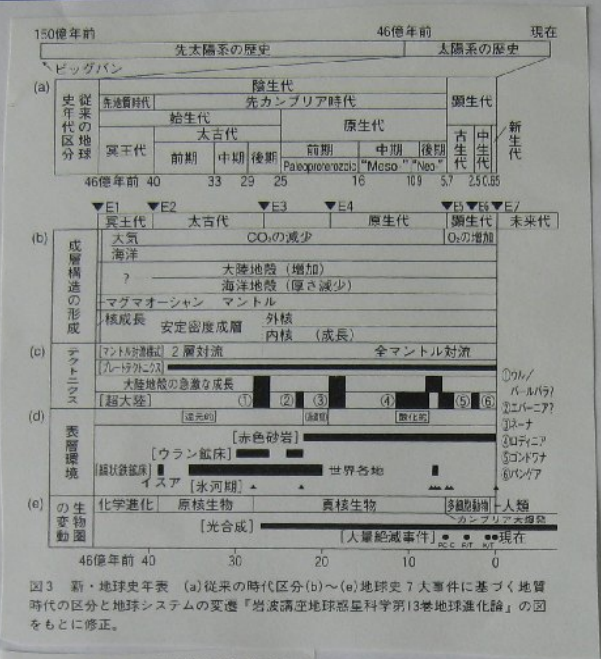


図3 新・地球史年表 (a)従来の時代区分(b)～(e)地球史7大事件に基づく地質時代の区分と地球システムの変遷「岩波講座地球惑星科学第13巻地球進化論」の図をもとに修正。

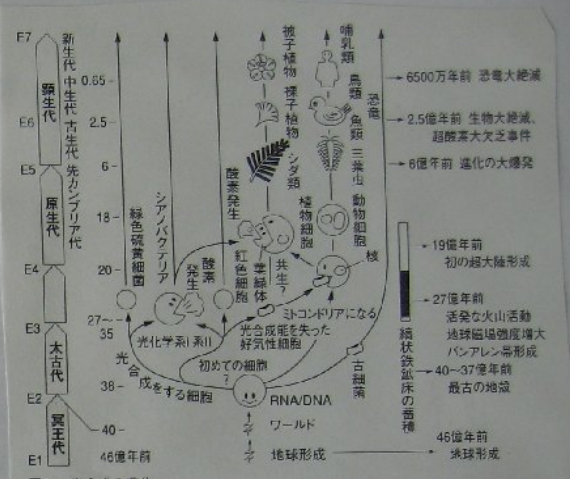


図23 光合成の進化

化学進化によって誕生した生命は、光合成を行うグループと光合成を行わないグループへ分かれていった。光合成を行うグループは、異なる光合成系をもつ緑色硫黄細菌と紅色硫黄細菌に分かれた。その後、これらの光合成細菌のもっていた2つの光合成がくみ合わさって、酸素発生を行うシアノバクテリアの光合成が誕生した。シアノバクテリアの光合成は、植物の光合成へと受けつがれていった。

伊藤・岩滝原図。「生きている地球の新しい見方」より。

図27 湯俣温泉の硫黄芝バイオマット

温泉水の流れる川底や小石の表面に繊維状のマットが形成されている。それらには硫黄が付着しており、白色ないし黄白色にみえる。温泉水の流れで、ゆらゆらとゆれている姿が芝のようにみえるので、硫黄芝と名づけられた。

Authors point to cap carbonate abruptly above glaciomarine dropstones in Namibia

Snowball Earth
Paul F. Hoffman + Web 5?

Stratigraphic expression of snowball episode on the rim of the Congo platform in Namibia

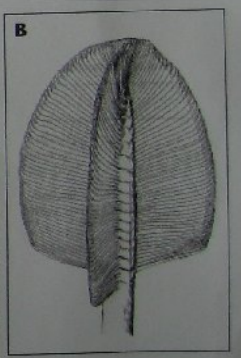


Figure 1. Photograph and artist's reconstruction of the holotype of *Swartpuntia germsi* from Namibia. For simplicity, only three petaloids are shown. Metric scale. After Narbonne et al. (1997, Figs. 5 and 8).

Through the climate debates:

1. Complex and mysterious coupling between atmosphere and sea surface.
2. In a geological time scale, the estimation about paleo-climates are not reliable yet.
3. Super computer modelling and precise data acquisition from satellite are now collaborating.
4. Earth has experienced more severe climates since its born.
5. What and How is our sustainable civilization beyond near future?
6. Is normal or abnormal recent climate?

Climate 2: Why so complicated?

<Key words>

***Negative and Positive feedback loops**
***Thresholds and buffer system**
***Non linear formulas and chaotic behaviour**
***Ocean as a huge thermal delay unit**
***Oscillations and resonances**

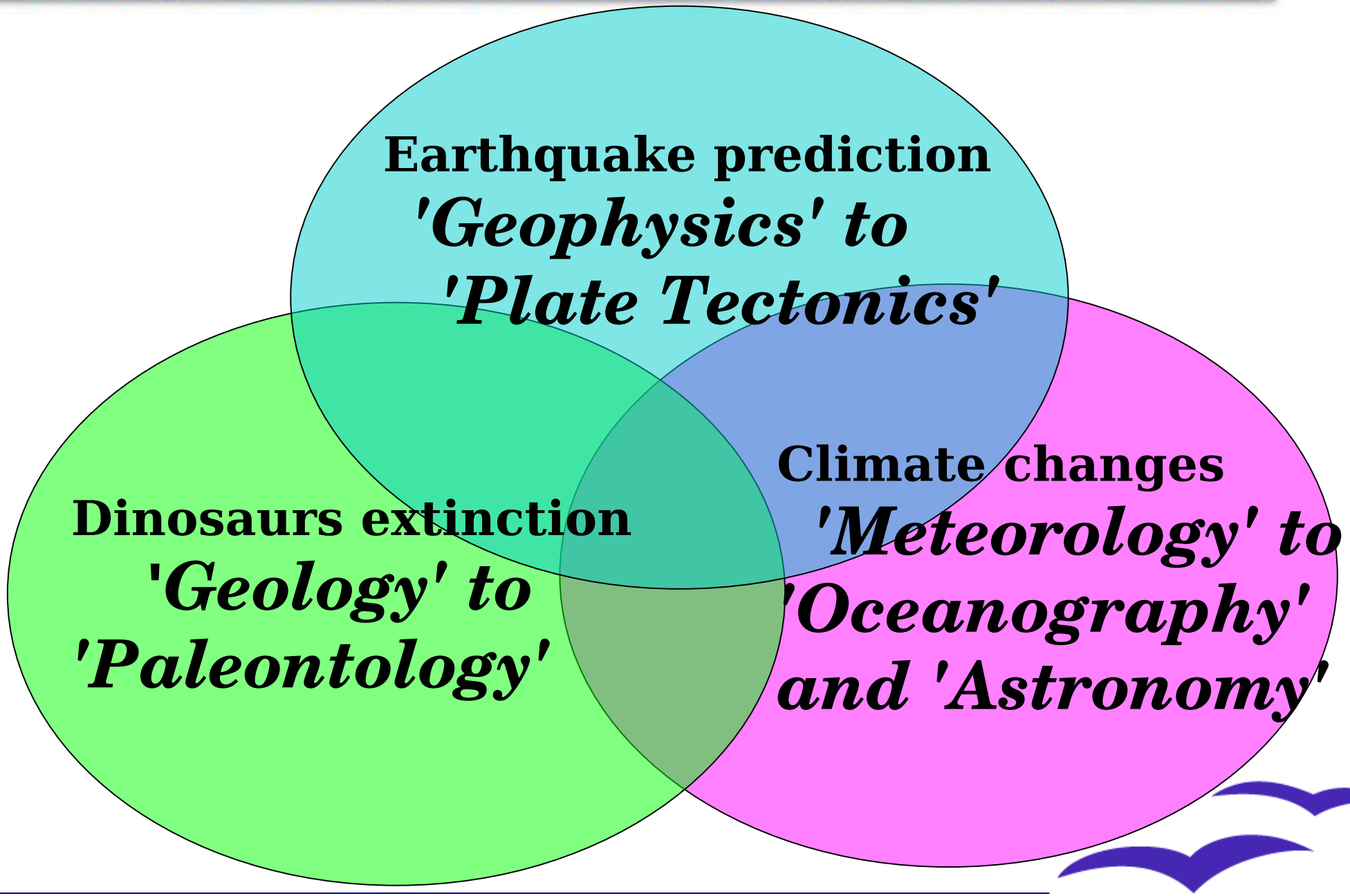
<Survey area of System technology>

***Climate is a most important example which students learn how 'Earth system' works.**
*** It can be substituted by electric circuits.**
*** 'Earth system science' should be modified with such technological view points.**

Through the all debates:

1. Are the nature and our existence deterministic or stochastic?
 --> A limit of scientific prediction.
2. How to exclude skepticism and 'pseudo-sciences'.
3. Imagine the natural catastrophes beyond our abilities.--> Impact, volcanic eruption and the climate crisis, even 'freezing earth?'.
4.'Gradualism' is attacked by 'Catastrophism'.
5. Tenacity of the species lived on the earth.
6. Social or Economical force versus Science
7. Scientists are respectable species-----!?.
8. How to construct and test hypothesis.
9. Establishing our discipline for a system sized natural catastrophe-----. And more-----

In the Future: Three axes extend to whole area



Merit

- **Current earth-scientific issues are novel and interesting for students.**
- **The debates give students an opportunity to think about survival of our civilization.**
- **They might construct their own attitude and discipline against natural disasters.**
- **Science is not full-time all mighty or complete but never hopeless for our future.**
- **Students can understand the advanced scientific technologies and research methods through these debates.**

Demerit

1. This method now has no systematic coverage to whole earth science.
2. So, these method has a weakness such as preparation for the entrance exams of Universities, which is most important issues in Japanese high school classes.
3. Combination with the traditional earth science method is still necessary.
4. Most of resources are written in English.
5. The debate are strongly biased

   if a teacher is a supporter of one side.

Conclusion

1. The rapid reconstruction for K-12 level earthscience education is aspired in Japan.
2. The websites showing earth science strongly inspire student's curiosity and also are quite suitable as teaching materials.
3. Students can understand how scientist research the nature and how construct the models and theories.
4. Models and simulations strongly help the student's learning skills up in ES.
5. Finally, the students have confidences against natural catastrophes.

*We should make earth science high enough as not a endangered species but a Phoenix!

Acknowledgements and Ref. books

- **Discussion around “the 1995 Kobe earthquake disaster” with Mr.Tatsuya Sugoshi strongly drives me to integrate this study. Also, we thanks to our geoscience class students for their helpful suggestions. This study was partly supported by G.I.A for scientific research 17914008 from the Ministry of Education, Culture, Sports, Science and Technology, Japan.**

Reference books:

Resources will be updated on my web site soon.

http:www.osaka-kyoiku.ac.jp/~yossi

Thank you for your attention.

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Our school's one day field excursion at Sobura, Kaizuka city