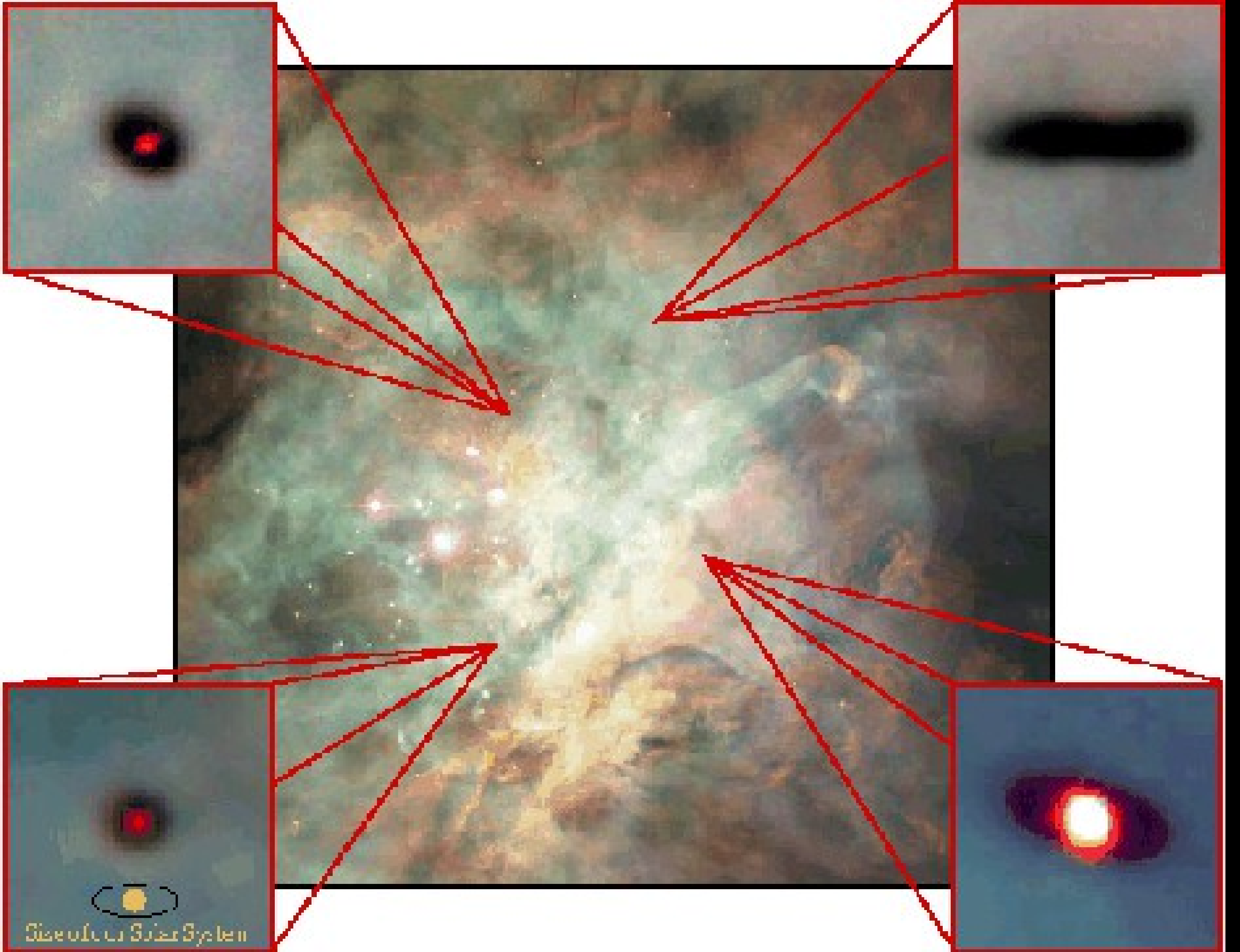
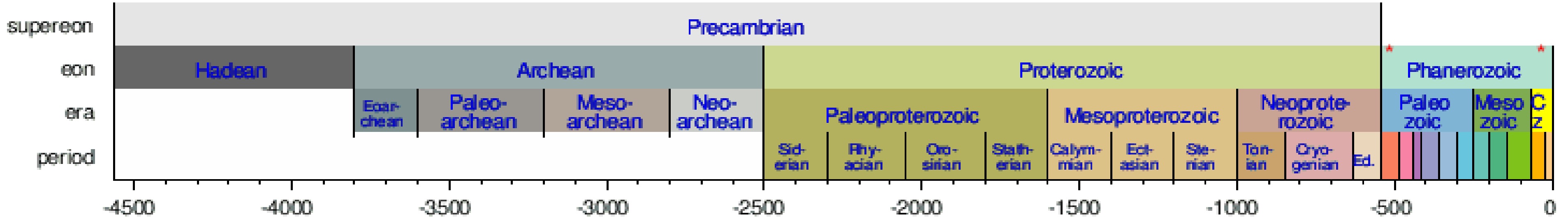
History of the life on Earth

Astronomical effects on the evolution of life and of mankind

Astronomical phenomena probably triggered many of the changes in the evolution.

Asteroid impacts, orbital forcing on climate, …

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Archean
Proterozoic
Phanerozoic
Eoar-
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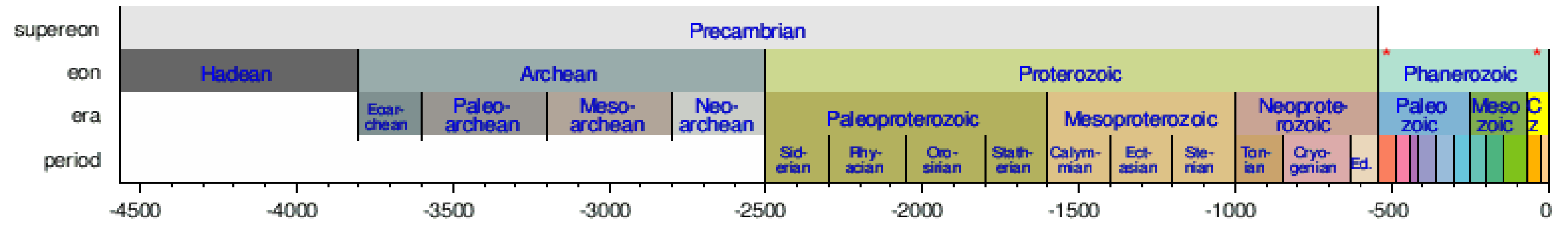
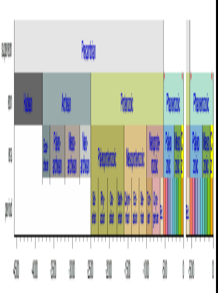
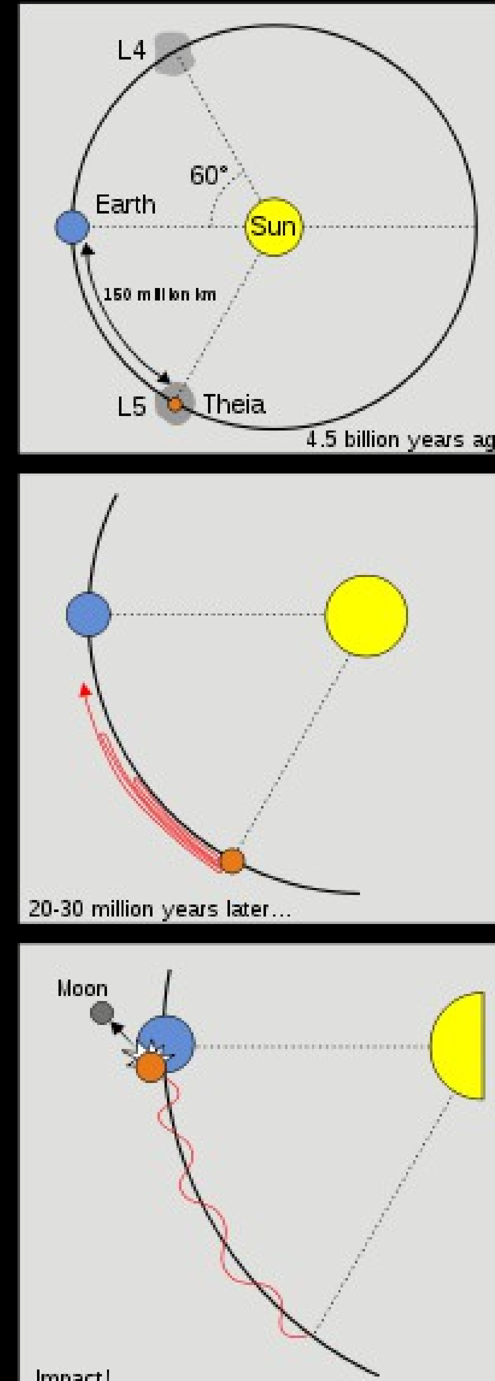
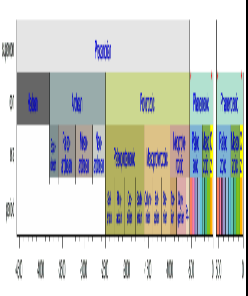


Formation of Earth, 4570 million

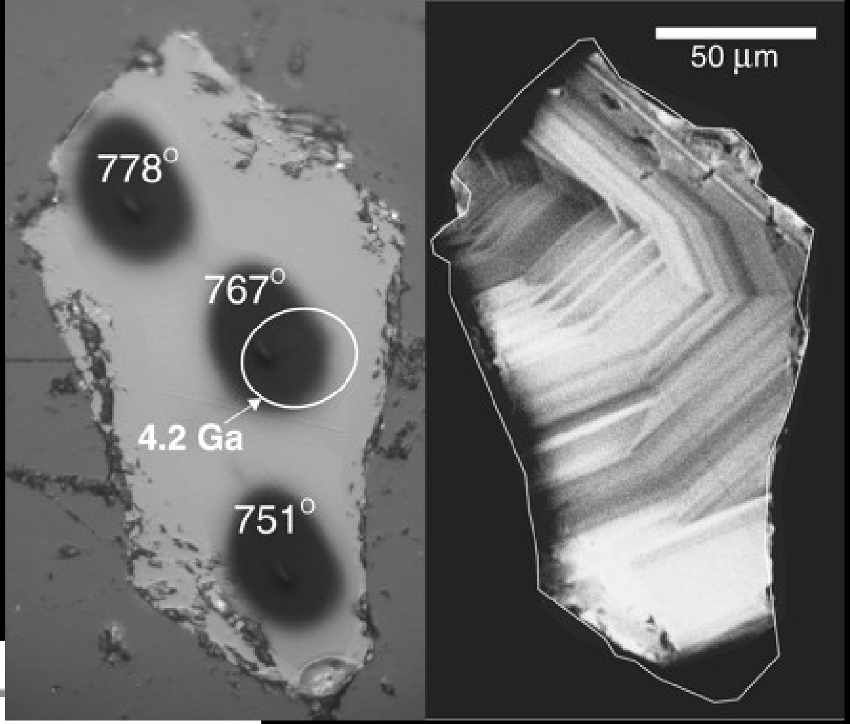




Formation of the Moon, 4500 million years ago (m.y.a.)

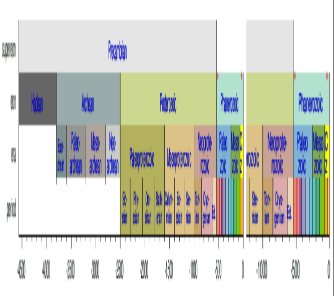


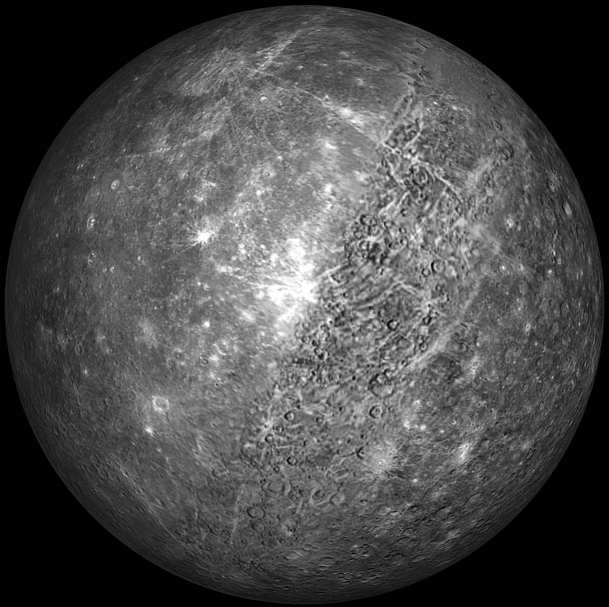
The oldest known mineral, zircon, 4400 million years ago



NATURE|Vol 448|23 August 2007

Figure 1 | Treasure trove. Menneken and colleagues[1] found diamonds in zircons, the earliest known remnants of Earth's crustal rocks that occur in conglomerates at Jack Hills in Western Australia.

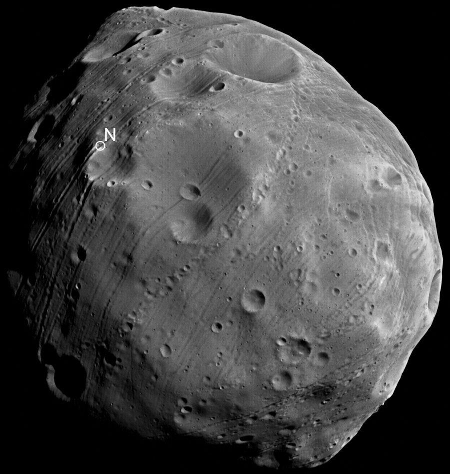




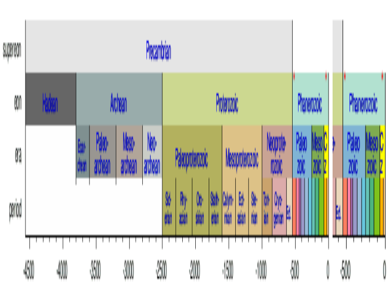
Mercury

Moon

Asteroids

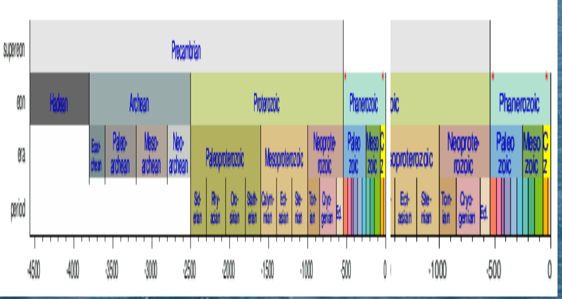


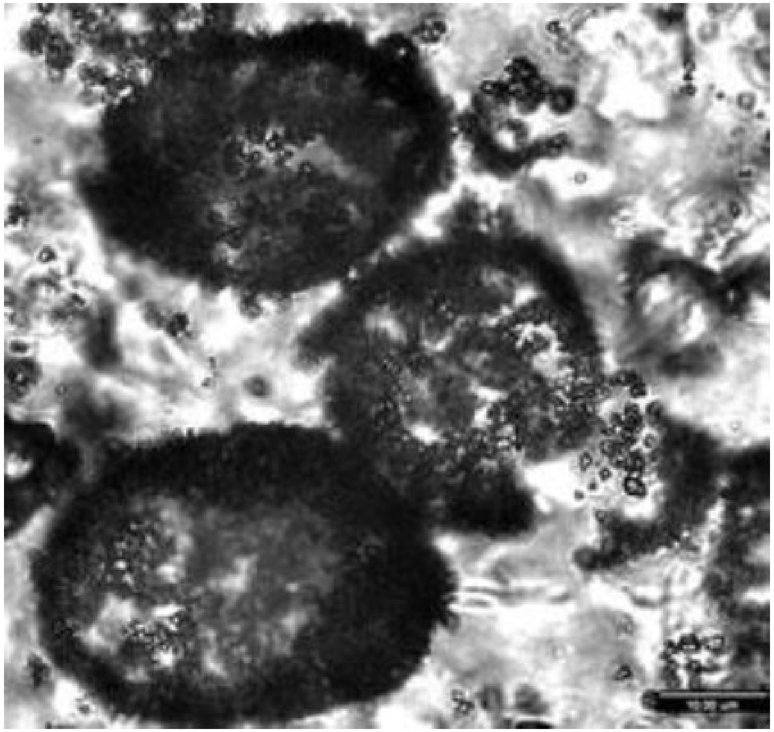
Beginning of the Late Heavy Bombardment 4150 million years ago. End: about 3850 m.y.a.



Older than dirt. Rocks by Hudson Bay may date back to when Earth first separated its primordial stuff into mantle and crust.

Oldest rocks. 4000 m.y.a.

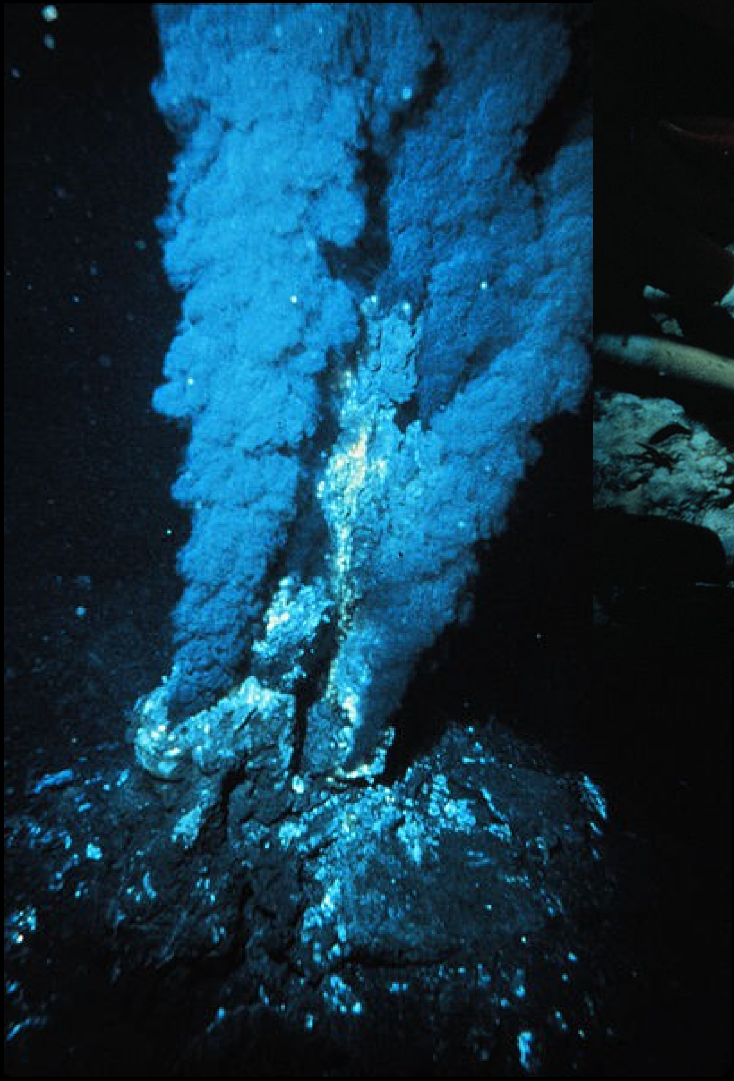
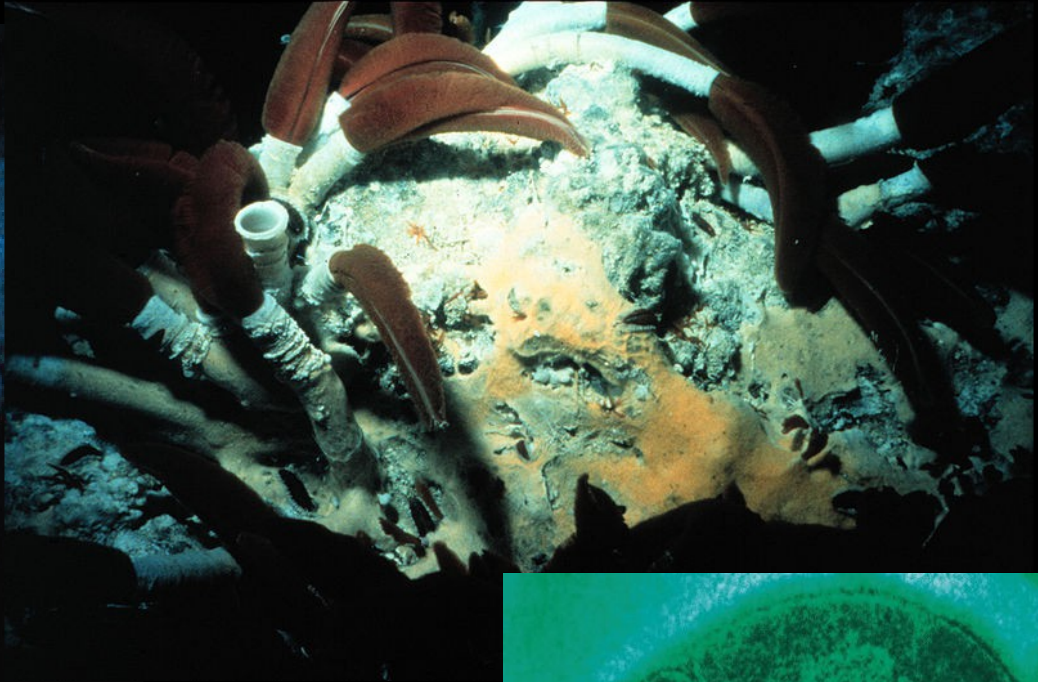
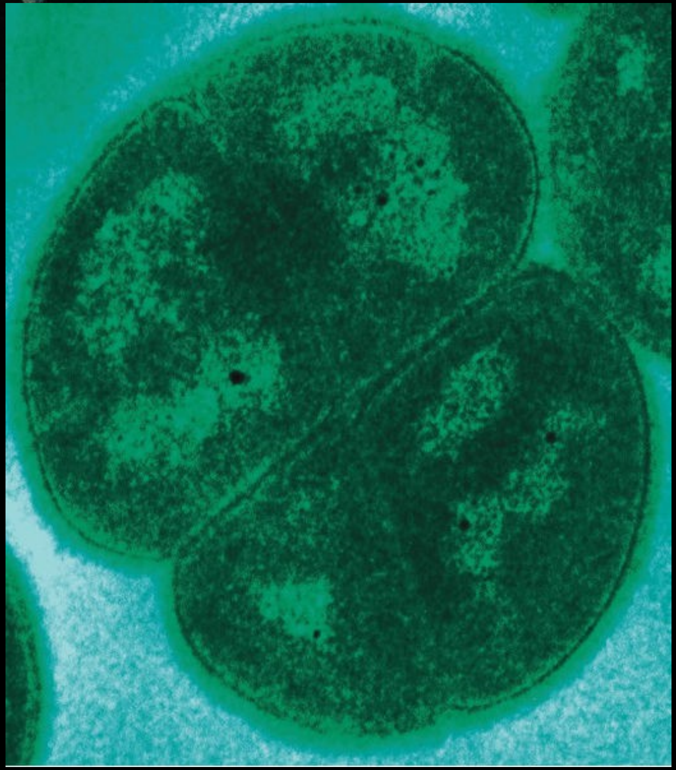




The fossils' size, shape and chemical composition suggests that they are the remains of microbial life.

D. Wacey/UWA

Single cells, bacteria and archaea, about 3800 m.y.a.
First fossils, about 3400 m.y.a.

Extremophil organisms

Molecule	Designation
c-C2H4O	Ethylene oxide
CH3C2H	Methylacetylene
H3CNH2	Methylamine
CH2CHCN	Acrylonitrile
H2CHCOH	Vinyl alcohol
C6H	Hexatriynyl
HC4CN	Cyanodiacetylene
CH3CHO	Acetaldehyde

Molecule	Designation
H3CC2CN	Methylcyanoacetylene
H2COHCHO	Glycolaldehyde
HCOOCH3	Methyl formate
CH3COOH	Acetic acid
H2C6	Hexapentaenylidene
CH2CHCHO	Propenal
CH2CCHCN	Cyanoallene
C7H	Heptatrienyl radical
NH2CH2CN	Aminoacetonitrile

Interstellar molecules

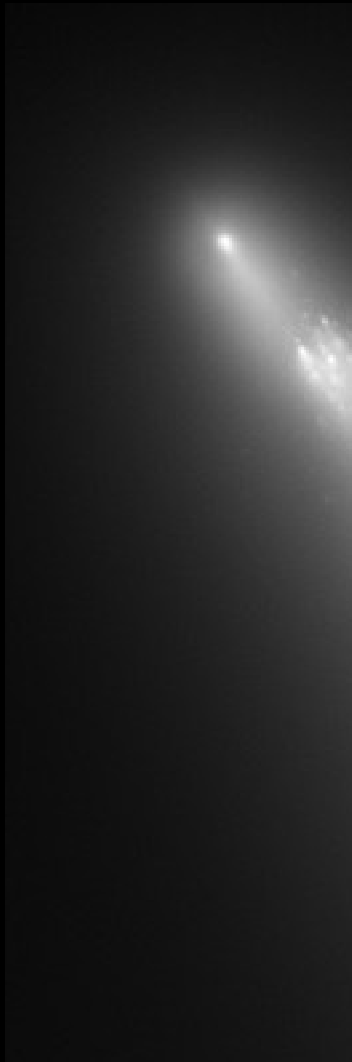
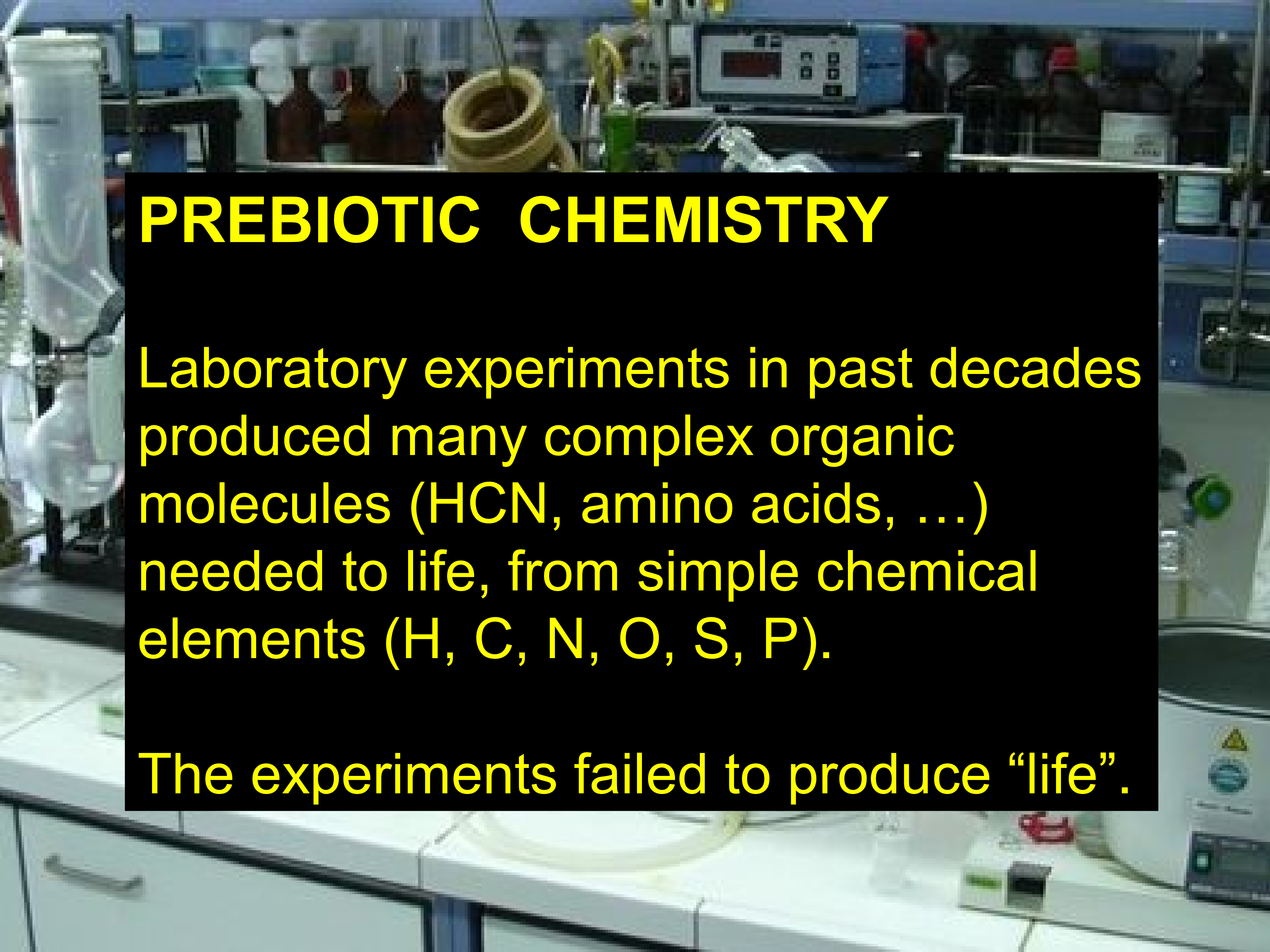


Table 2 Biochemical monomers and properties that can be derived from interstellar and cometary molecules[a]

Interstellar and cometary molecules	Formulae	Biochemical monomers and properties
1. Hydrogen	H_2	Reducing agent
2. Water	H_2O	Universal solvent
3. Ammonia	NH_3	Catalysis and amination
4. Carbon monoxide	$CO(+H_2)$	Fatty acids
5. Formaldehyde	CH_2O	Ribose and glycerol
6. Acetaldehyde	$CH_3CHO(+CH_2O)$	Deoxyribose
7. Aldehydes	$RCHO(+HCN$ and $NH_3)$	Amino acids
8a. Hydrogen sulfide	H_2S(+other precursors)	Cysteine and methionine
8b. Thioformaldehyde (interstellar)	CH_2S	
9. Hydrogen cyanide	HCN	Purines and amino acids
10. Cyanacetylene (interstellar)	HC_3N(+cyanate)	Pyrimidines
11. Cyanamide (interstellar)	H_2NCN	Condensing agent for biopolymer synthesis
12a. Phosphorus nitride (interstellar)	PN	
12b. Phosphine (Jupiter and Saturn)	PH_3	Phosphates and nucleotides
12c. Phosphate[b]	PO_4^{3-}	

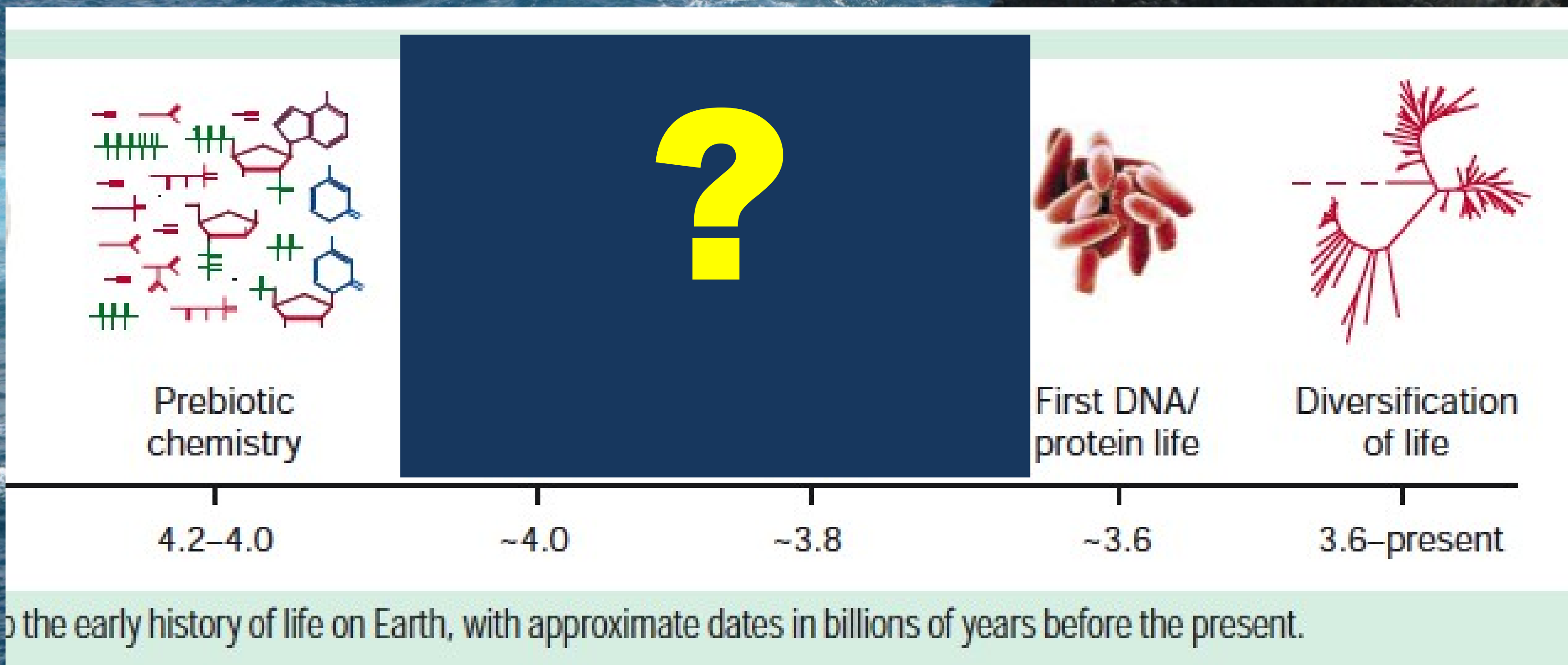
Comet 73P/Schwassmann–Wachmann observed in 1995



PREBIOTIC CHEMISTRY

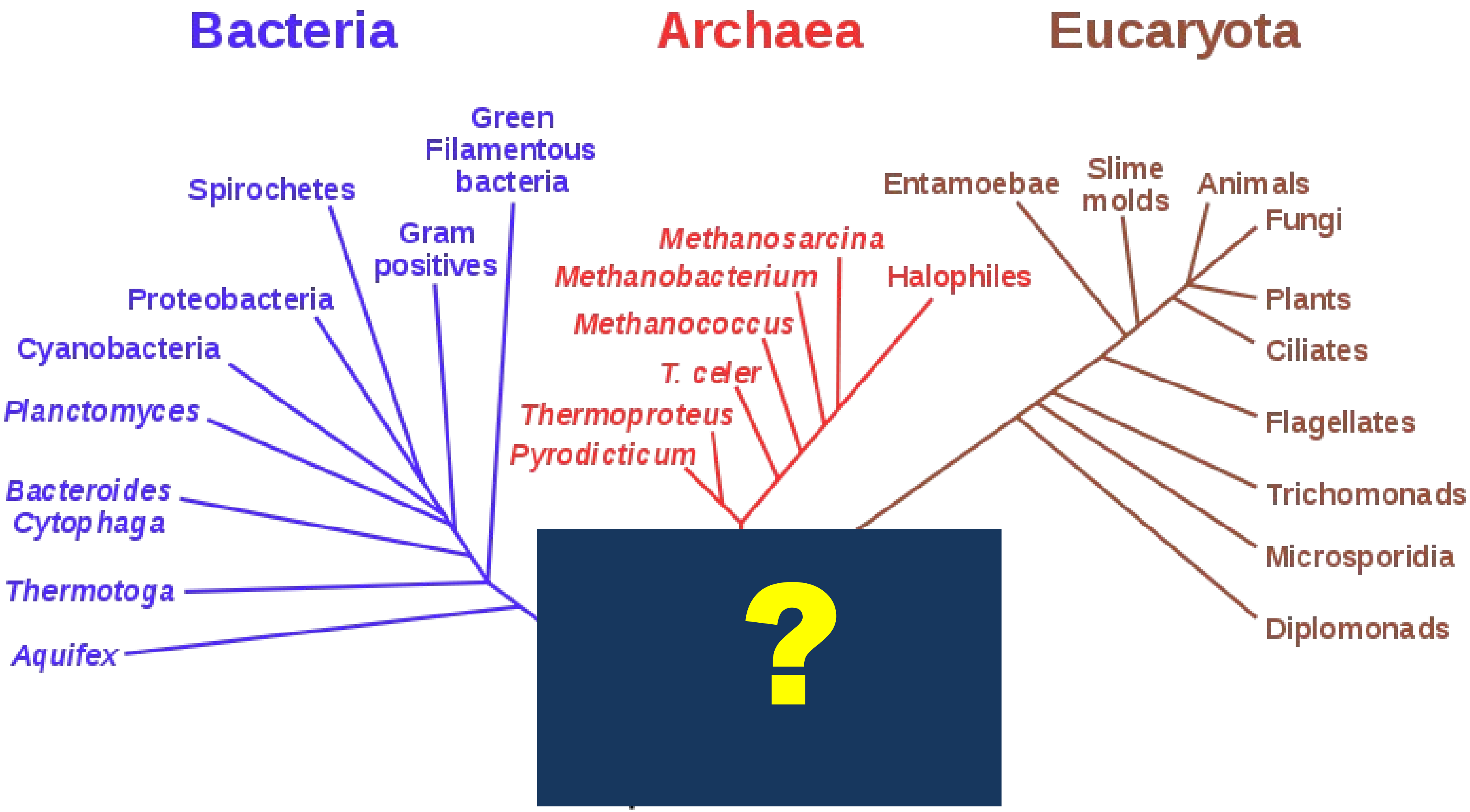
Laboratory experiments in past decades produced many complex organic molecules (HCN, amino acids, …) needed to life, from simple chemical elements (H, C, N, O, S, P).

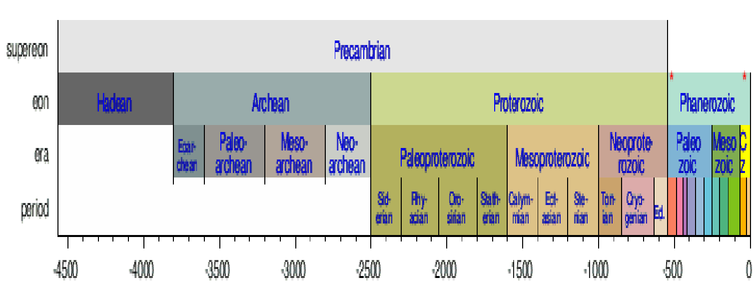
The experiments failed to produce “life”.

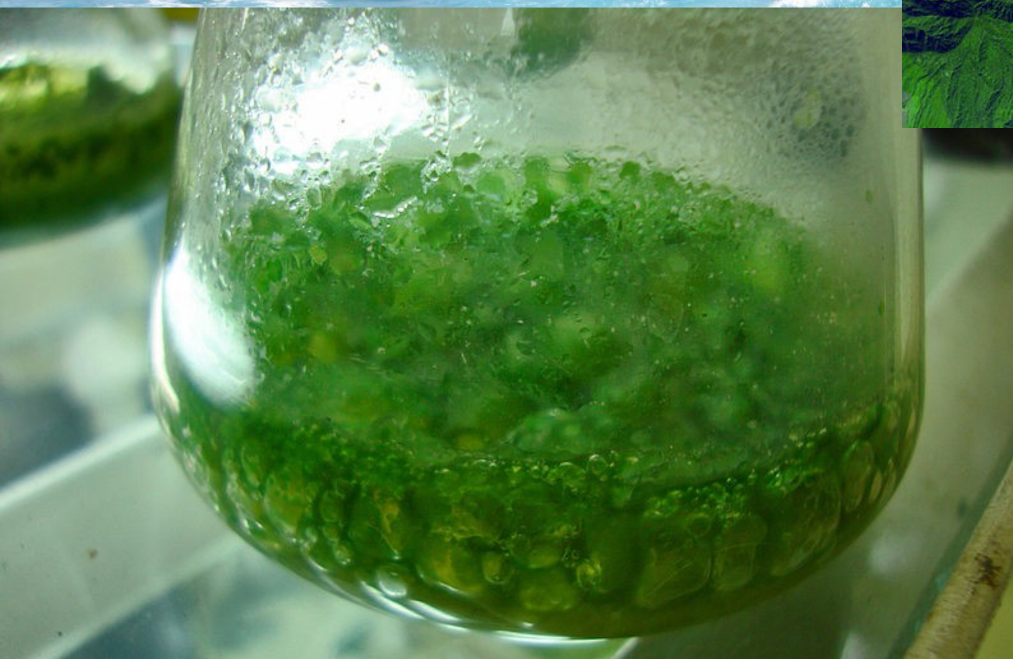


(G. Joyce, 2002, Nature)

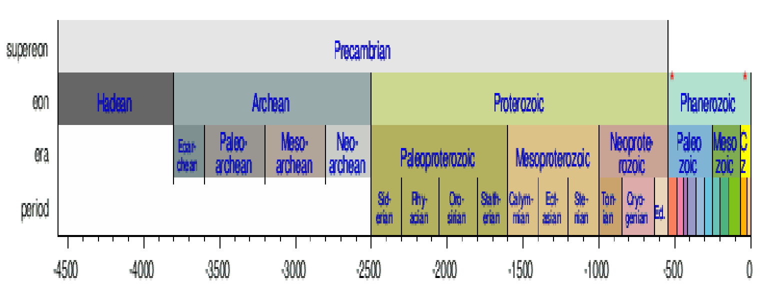
Phylogenetic Tree of Life



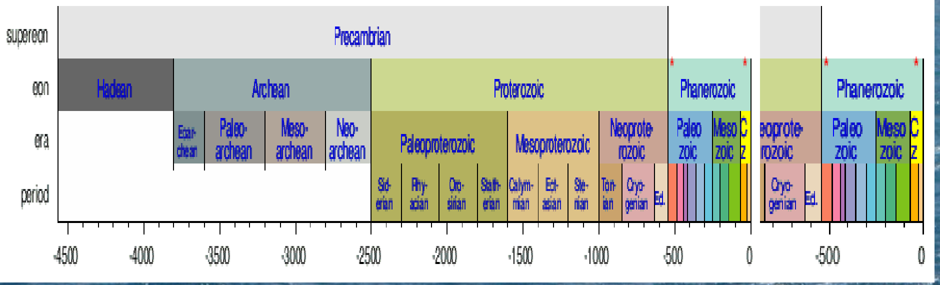




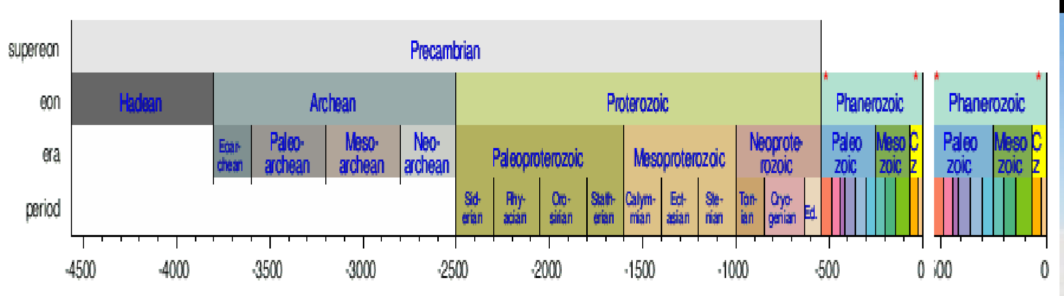
Cyanobacteria. Probable first cells 3400 m.y.a. First colonies about 3200 m.y.a. (macrofossils,



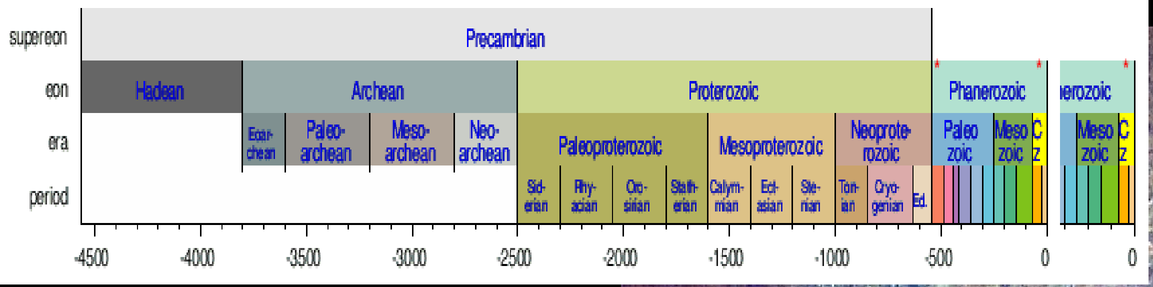
Earth surface: just “desert”.

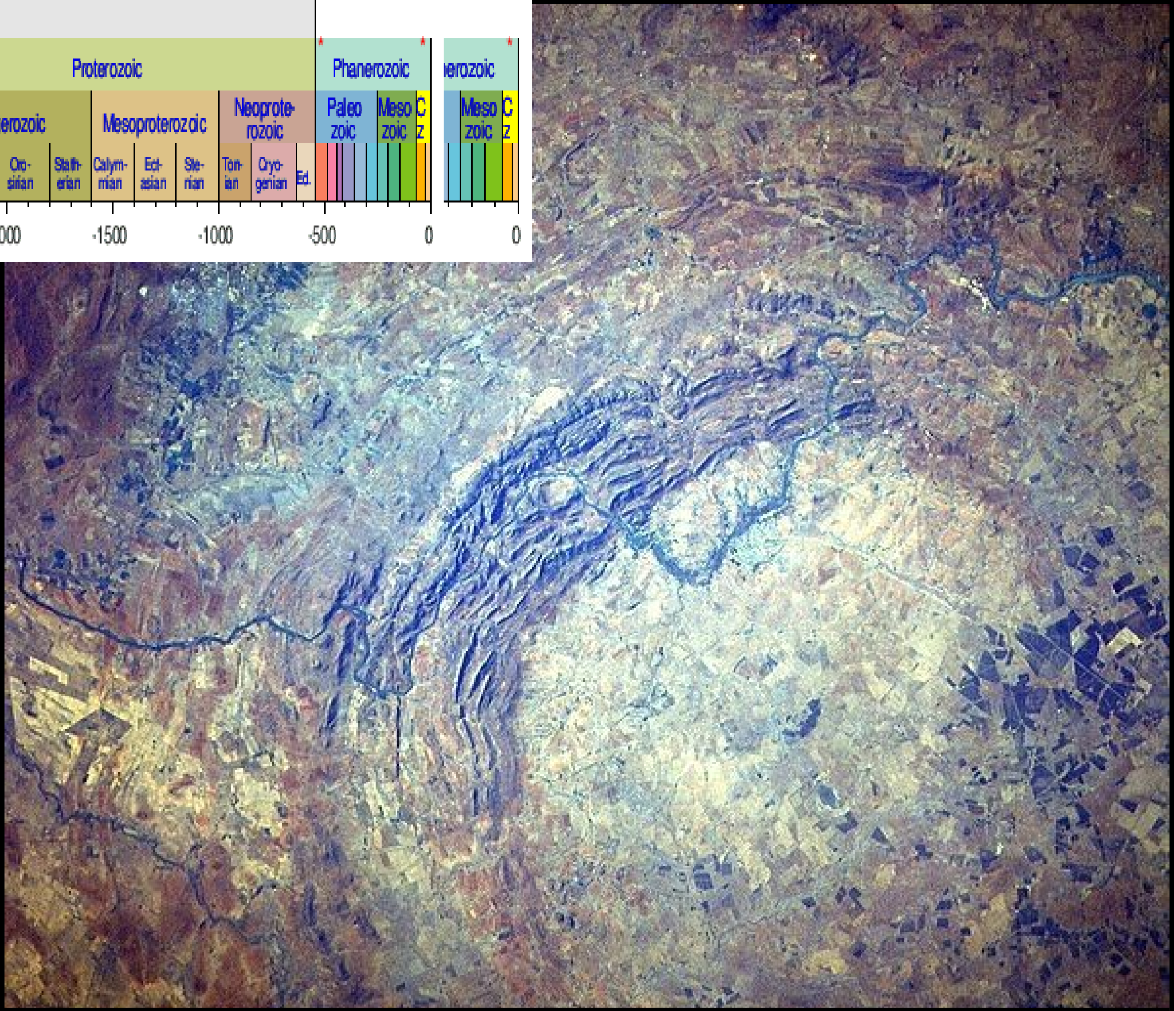


Oxygen catastrophe: banded iron formations. 2500 m.y.a.



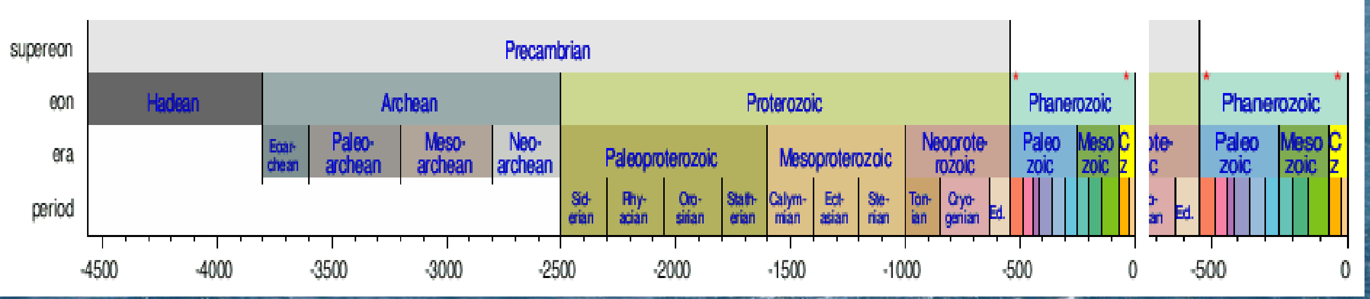
Huronian glaciation, from 2400 to 2100 m.y.a.

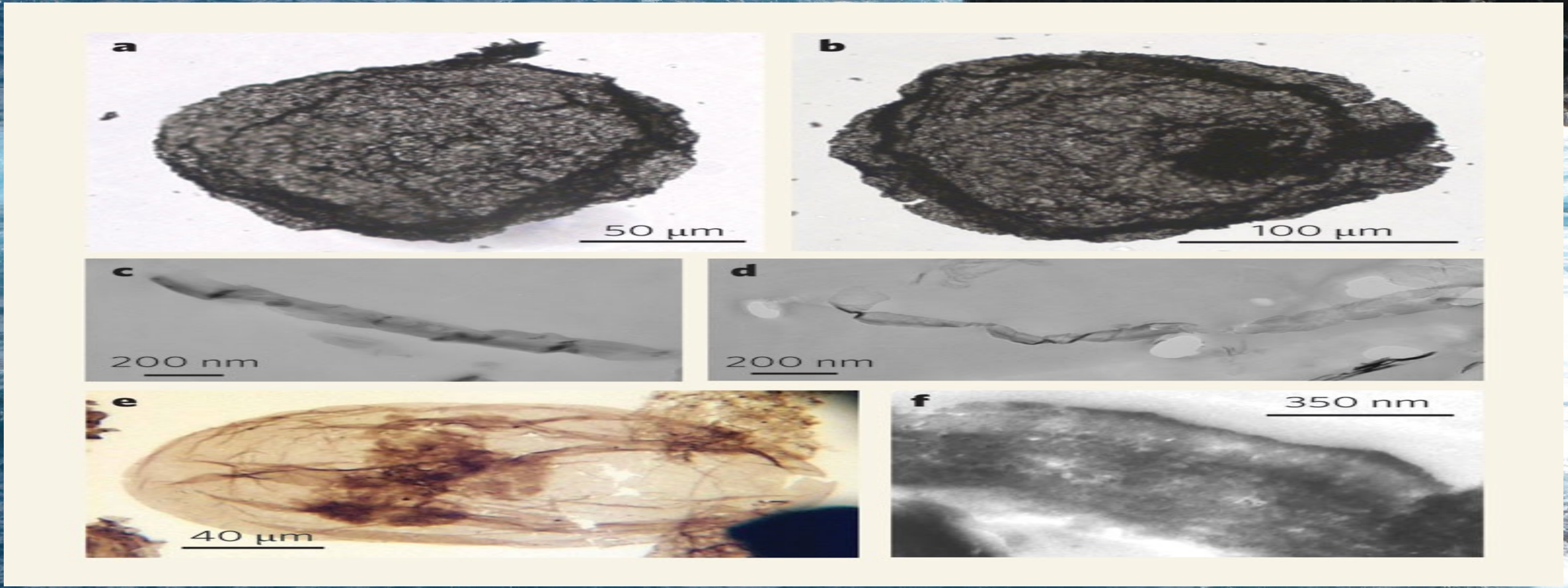




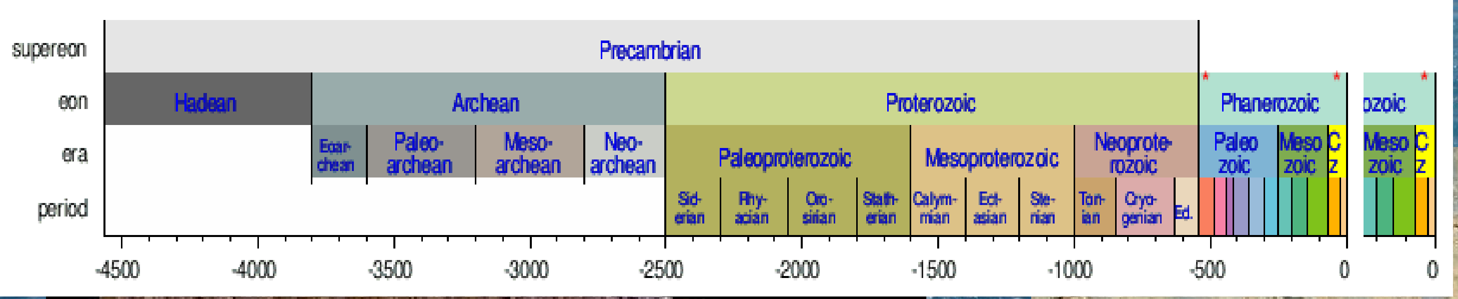
Vredefort (SudAfrica). 2023 m.y.a.
Condrite asteroid of 5-10 km. Crater of 300 km.

No extinctions, since there is not yet complex

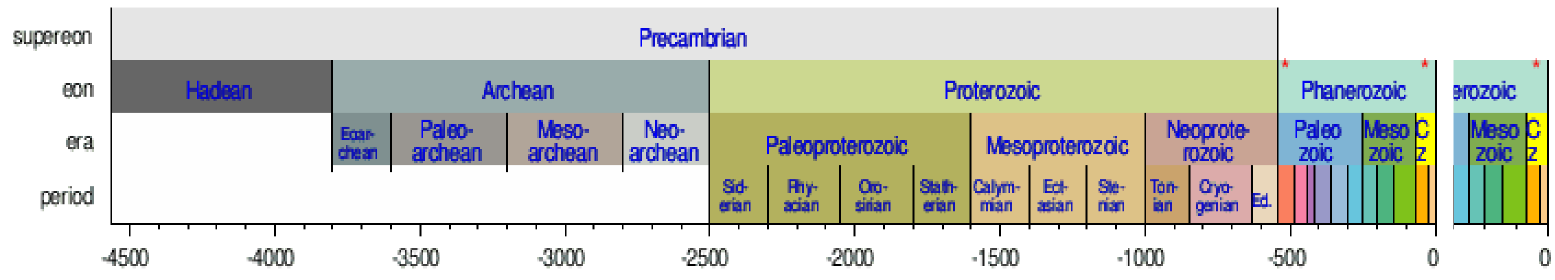




First cells with nucleus (eukaryota) 1400 m.y.a.



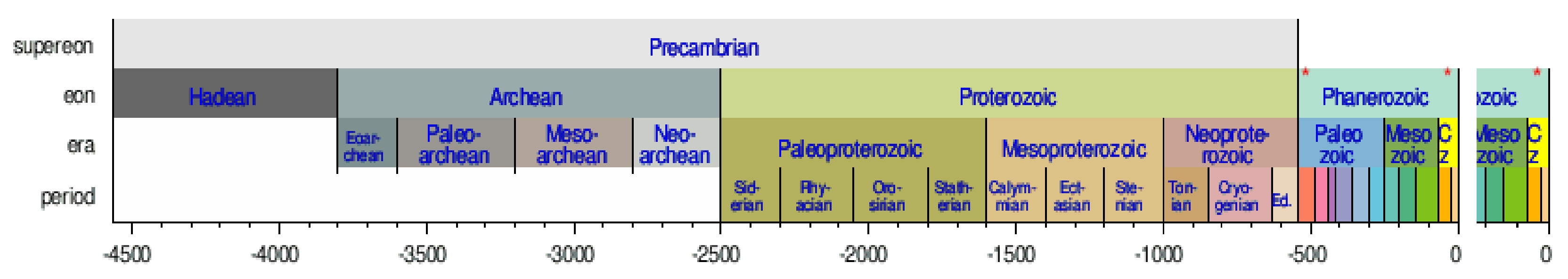
Stromatolites. Maximum cyanobacteria about 1200 m.y.a.



First simple multicellular organisms in the seas.

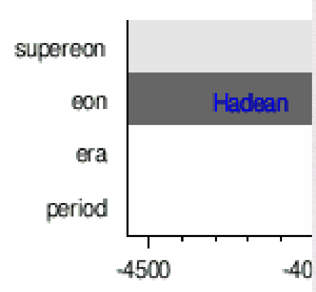
First single cells outside the seas.

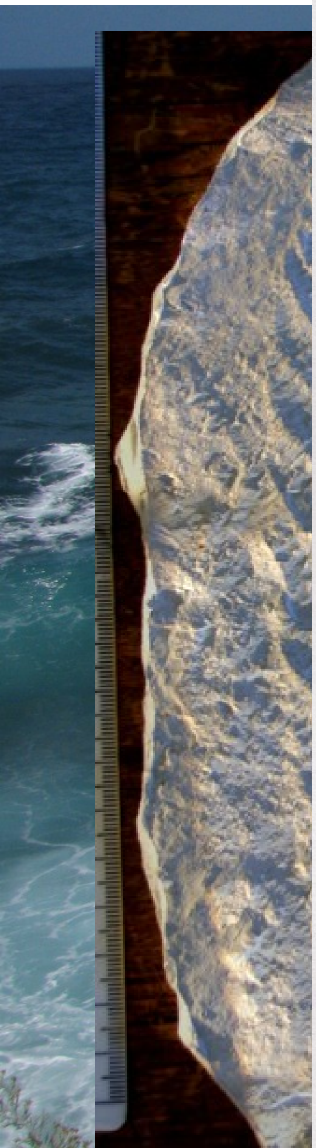
1000 m.y.a.



Snowball Earth.

About 850 – 630 m.y.a.





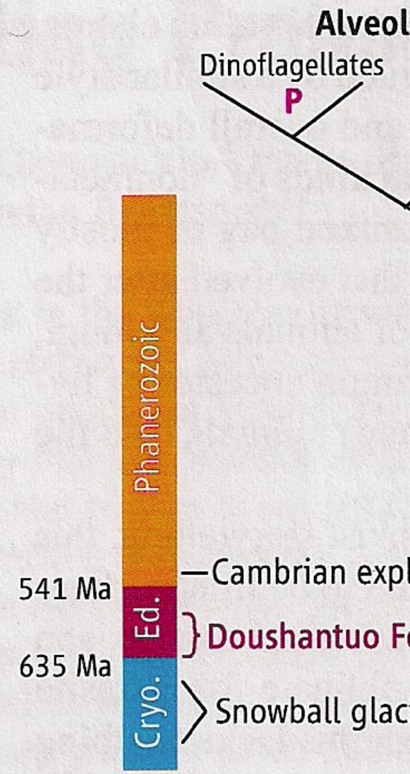
Science, 334, 1655; 23.12.2011

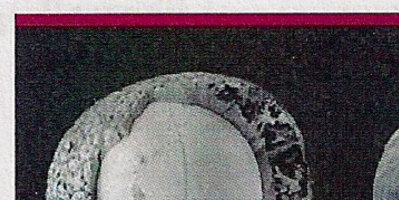
PALEONTOLOGY

Terminal Developments in Ediacaran Embryology

N. J. Butterfield

Ever since Darwin there has been a disturbing void, both paleontological and psychological, at the base of the Phanerozoic eon. If his theory of gradualistic evolution be true, then surely the pre-Phanerozoic oceans must have swarmed with living animals—despite their conspicuous absence from the early fossil record. Thus, the 1998 report of fossilized animal embryos in the early Ediacaran Doushantuo Formation of South China (*1*) was met with almost palpable relief. It was indeed the fossil record that had let us down, not the textbooks, and certainly not the exciting new insights from molecular clocks. All was not as it seemed, however, and new data from Huldtgren *et al.* on page 1696 of this issue (*2*) look set to revoke the status of these most celebrated Ediacaran fossils.





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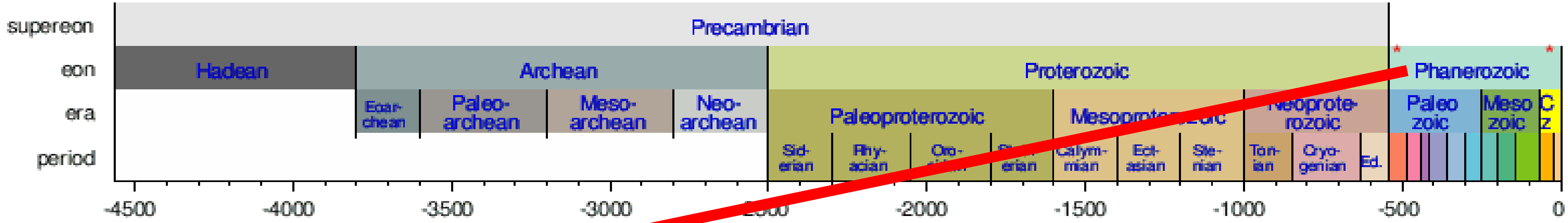
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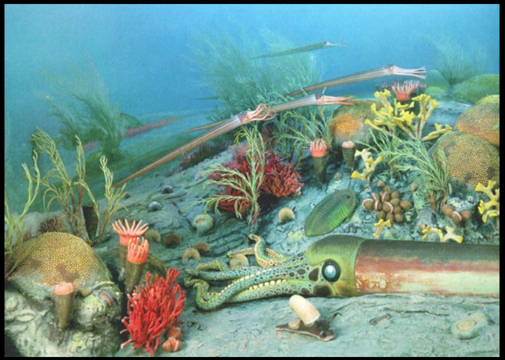
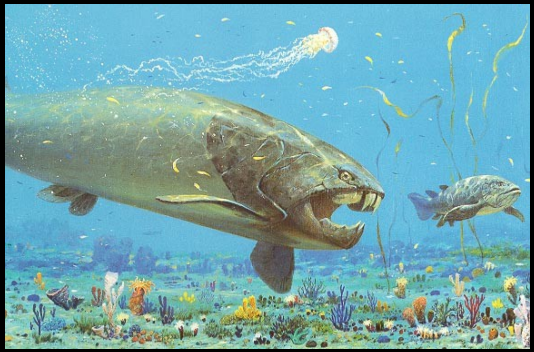
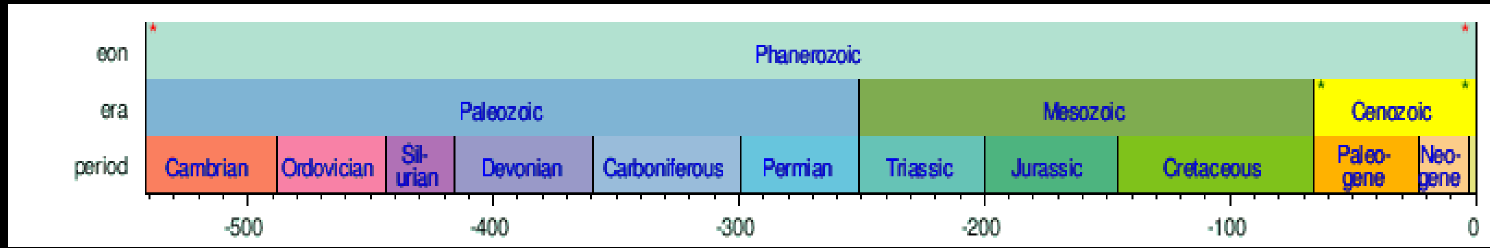
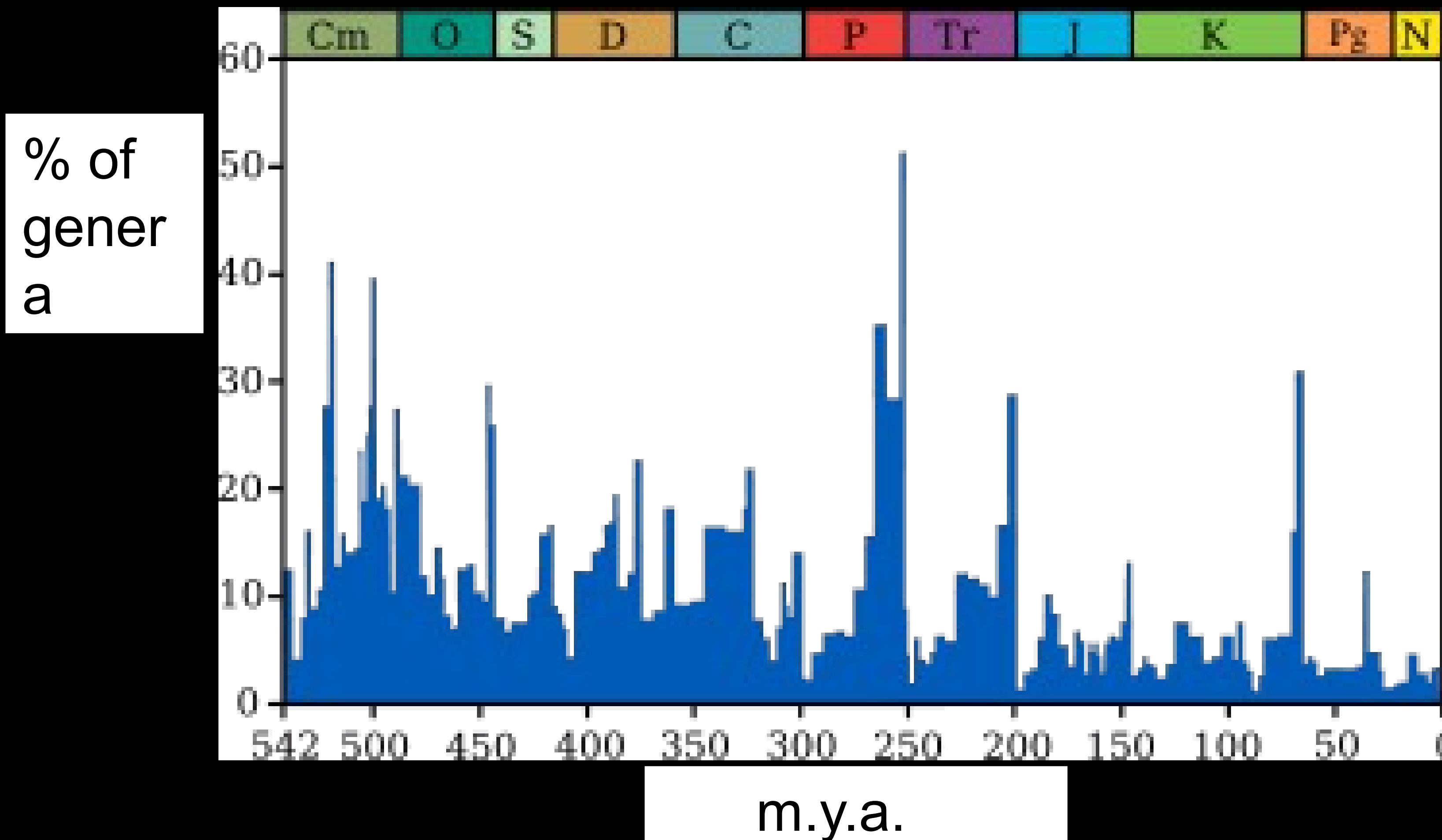


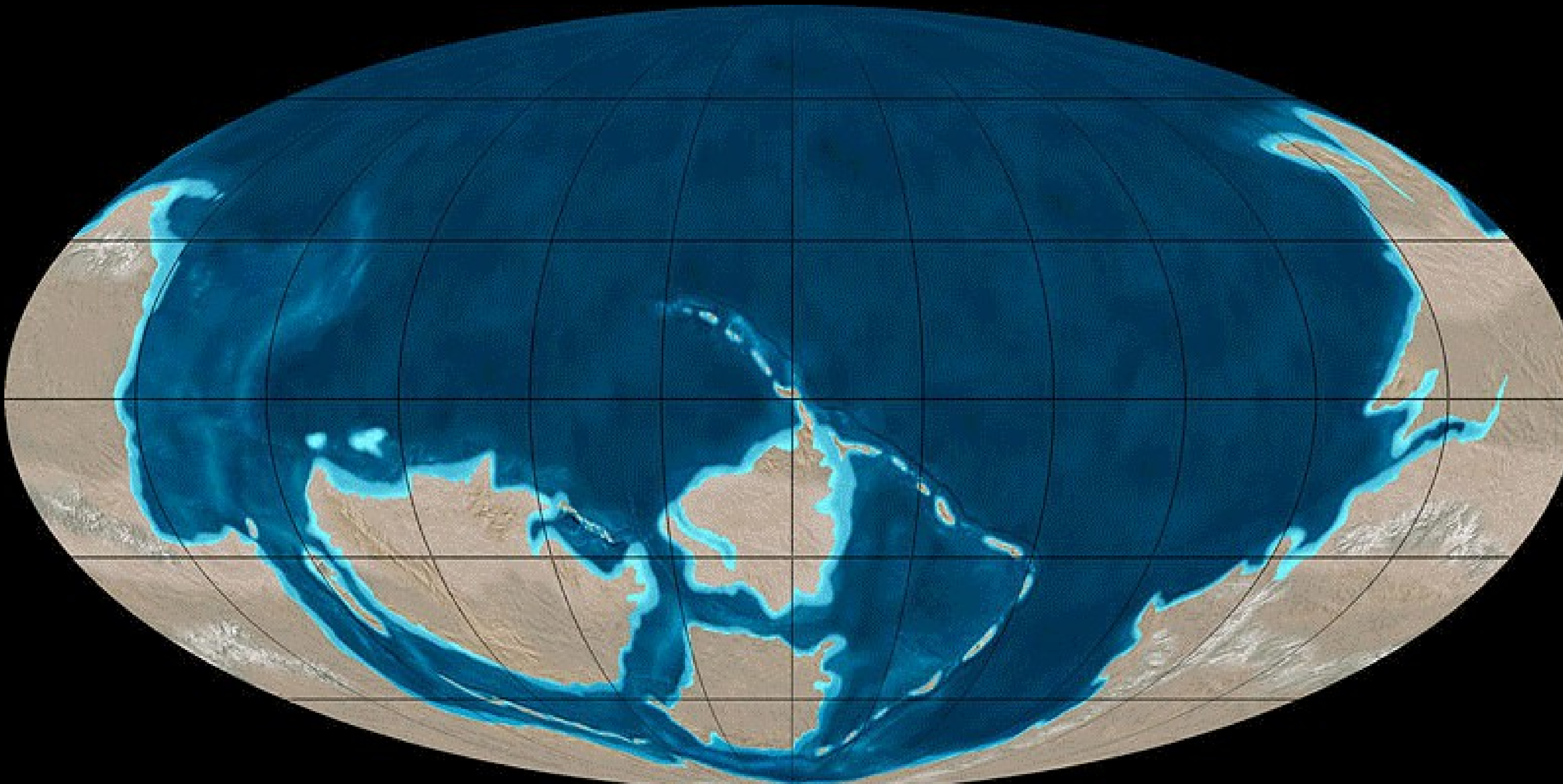




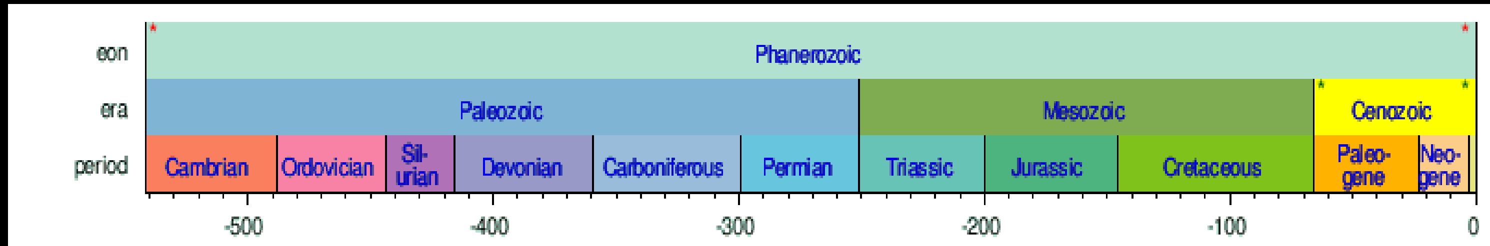



Mass extinctions in the seas



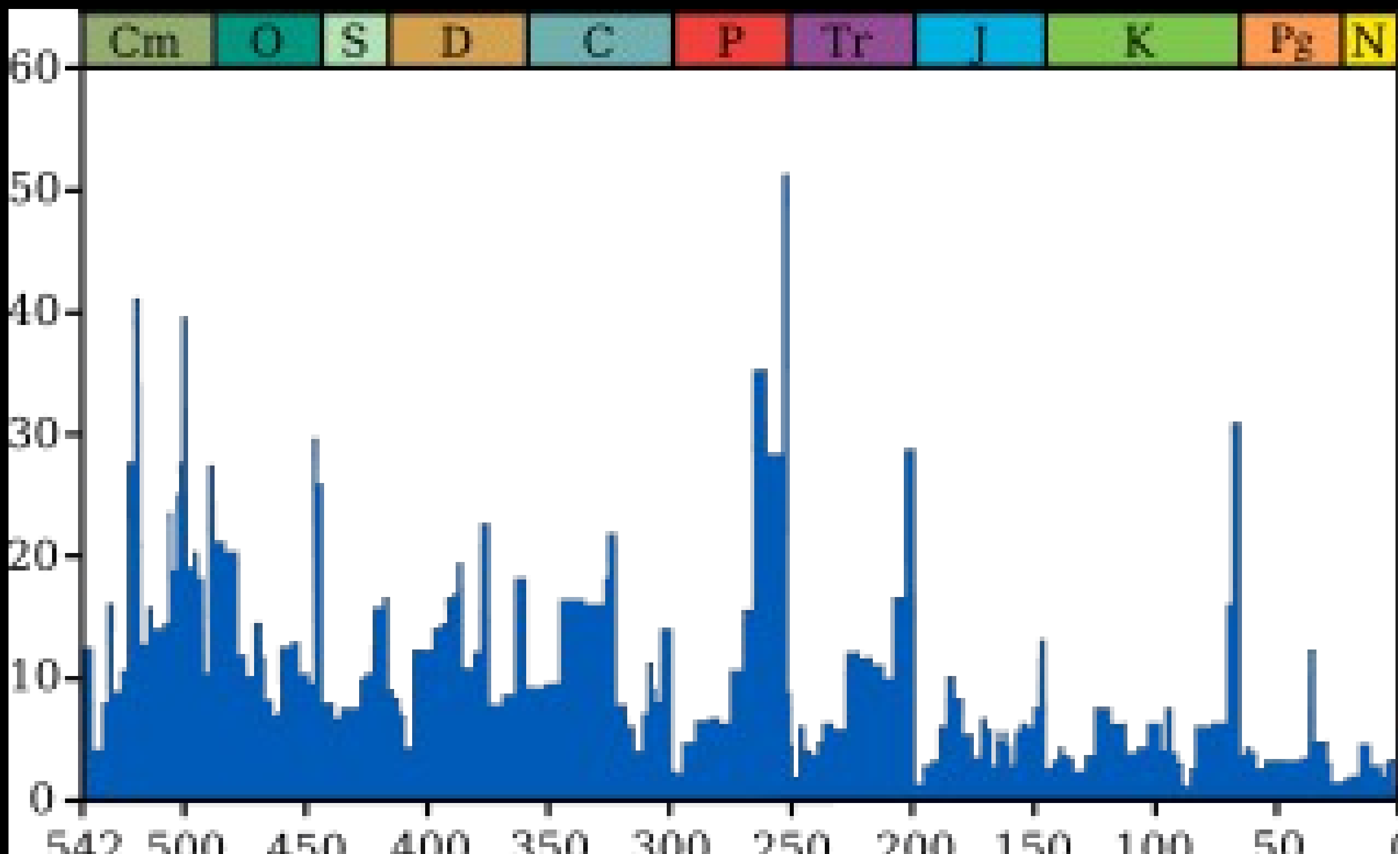


From 550 m.y.a. to present

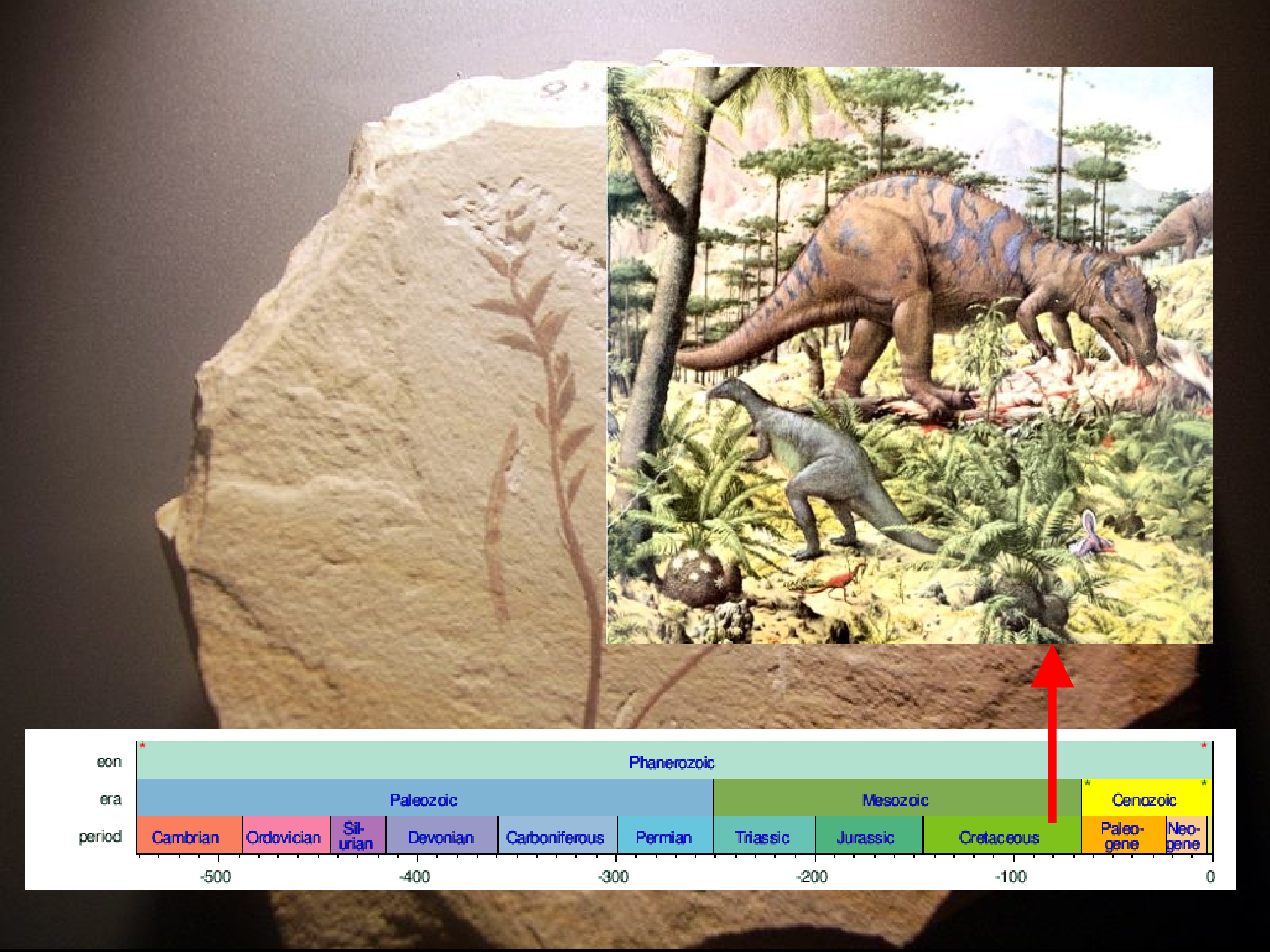


Mass extinctions in the seas

% of genera



m.y.a.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Paleozoic
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Cenozoic
Cambrian
Ordovician
Sil-
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Devonian
Carboniferous
Permian
Triassic
Jurassic
Cretaceous
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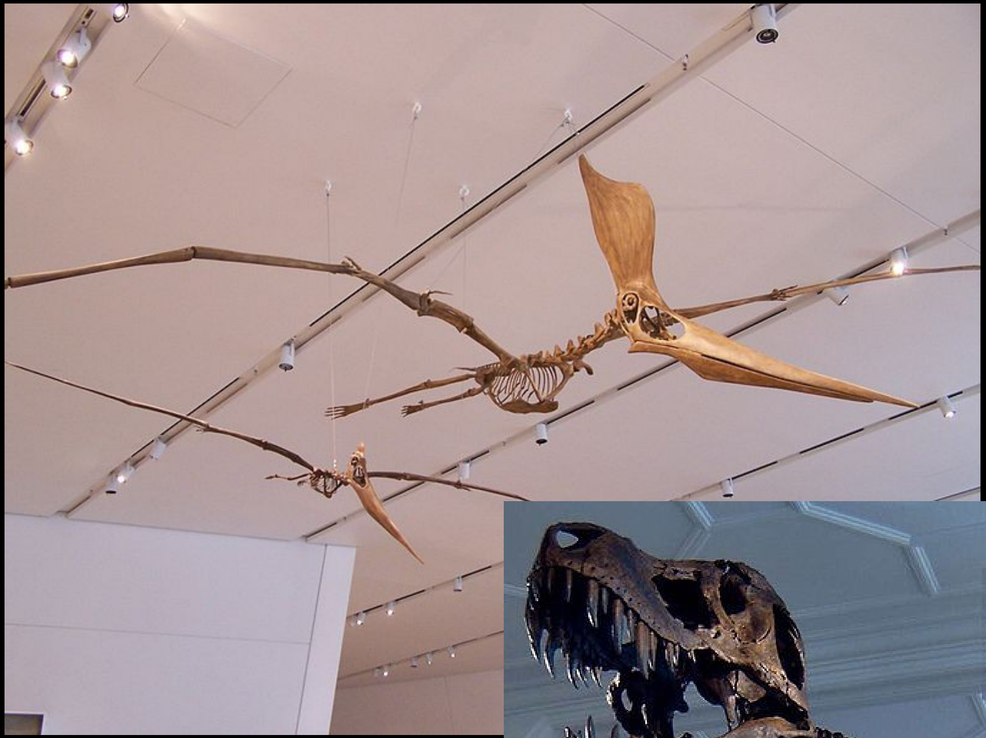


Extinction
Cretaceous-Palaeogene

seas

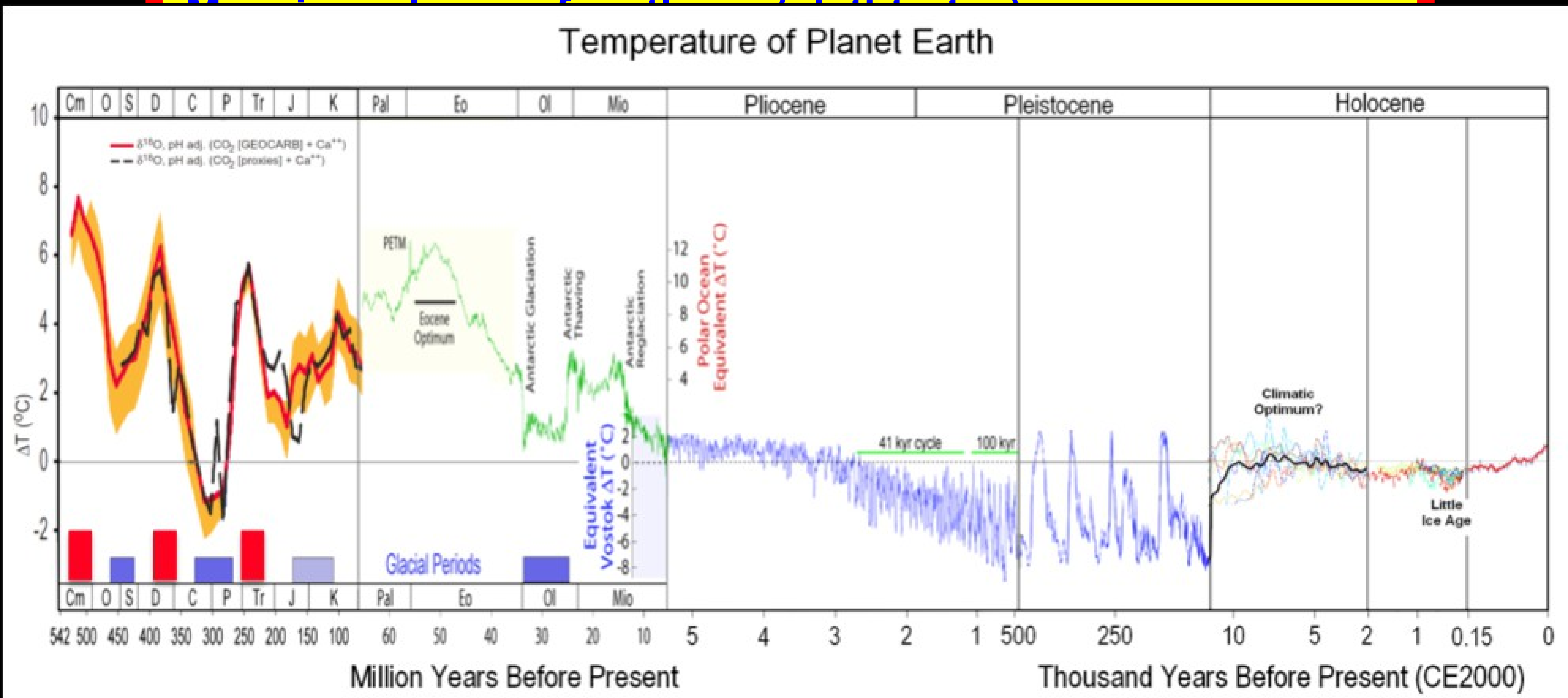
Oscillations up
Cosmic Rays
Nearby Supern
Companion sta
Variation of Ear
etc……

Hypotheses on the mass extinctions

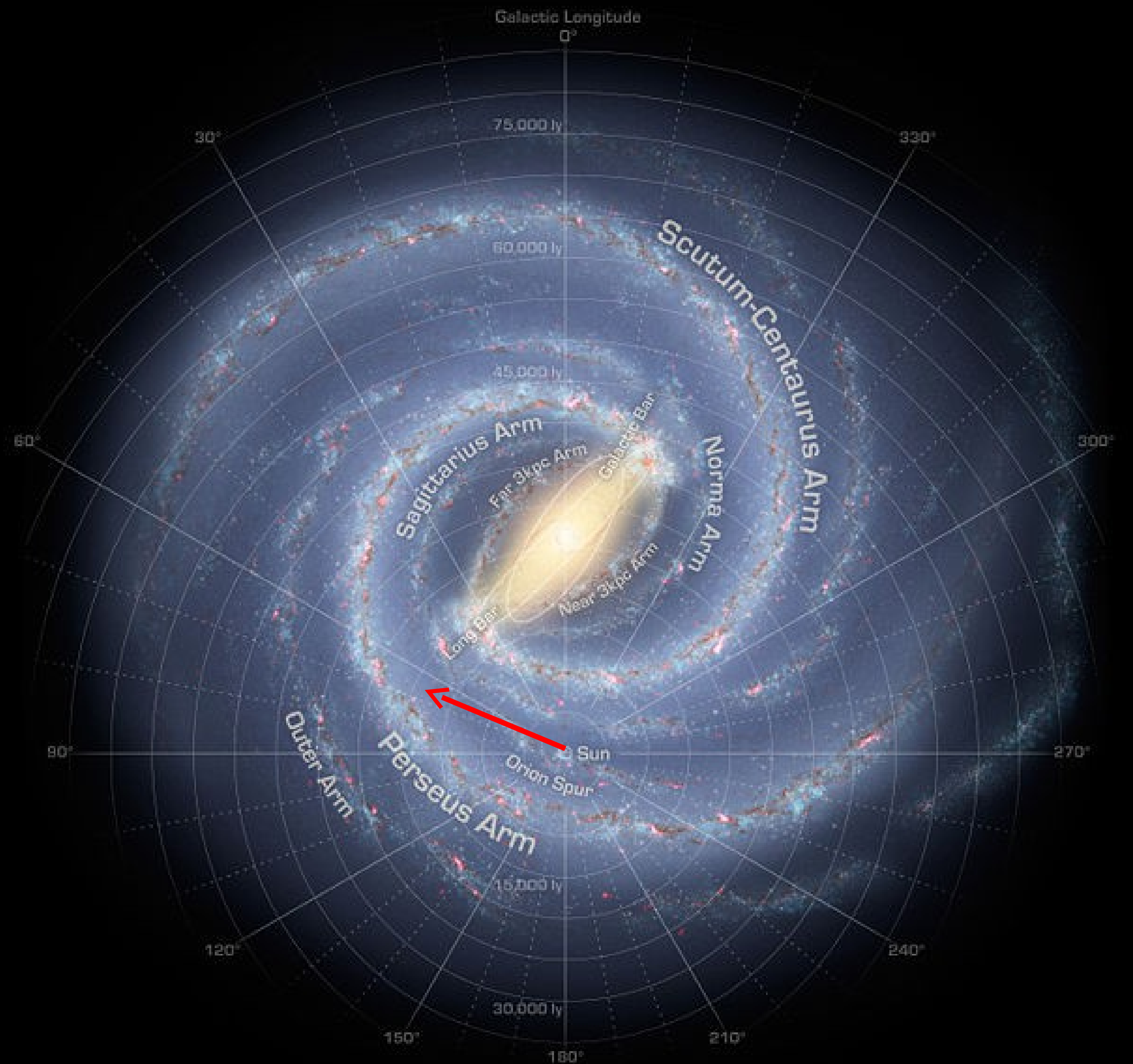
Flood basa
Massive re
Massive er
Sea-level f
Significant
Significant
Anoxic eve
Oceanic ov
Impacts of
Interstellar
Oscillation
Cosmic Ra
Nearby Su
Companion
Variation of Earth axis inclination
etc……

Hypotheses on the mass extinctions

Flood basalt events



etc……



Galactic Longitude
0°
30°
330°
60°
300°
90°
270°
120°
240°
150°
210°
180°
75,000 ly
60,000 ly
45,000 ly
15,000 ly
30,000 ly
Scutum-Centaurus Arm
Sagittarius Arm
Far 3kpc Arm
Galactic Bar
Norma Arm
Near 3kpc Arm
Long Bar
Outer Arm
Perseus Arm
Sun
Orion Spur

Hyp

Flood

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doi:10.1017/S147355040999005X

Introduction

Do astronomical phenomena have an impact on life on Earth? The answer is of course 'yes'. The seasons are a result of the Earth's orbit around the Sun and the ice ages over the past few hundred thousand years were almost certainly caused by well-understood changes in this orbit and the orientation of the Earth's axis. In this article I will primarily examine changes which took place over a longer timescale, tens or hundreds of millions of years. On these timescales other mechanisms connected to the orbit of the Sun around the Galaxy come into consideration, *a priori* at least. It is my objective to examine the evidence for and against various astronomical mechanisms for causing mass extinctions and/or climate change.

Near

Comp

Varia

etc…

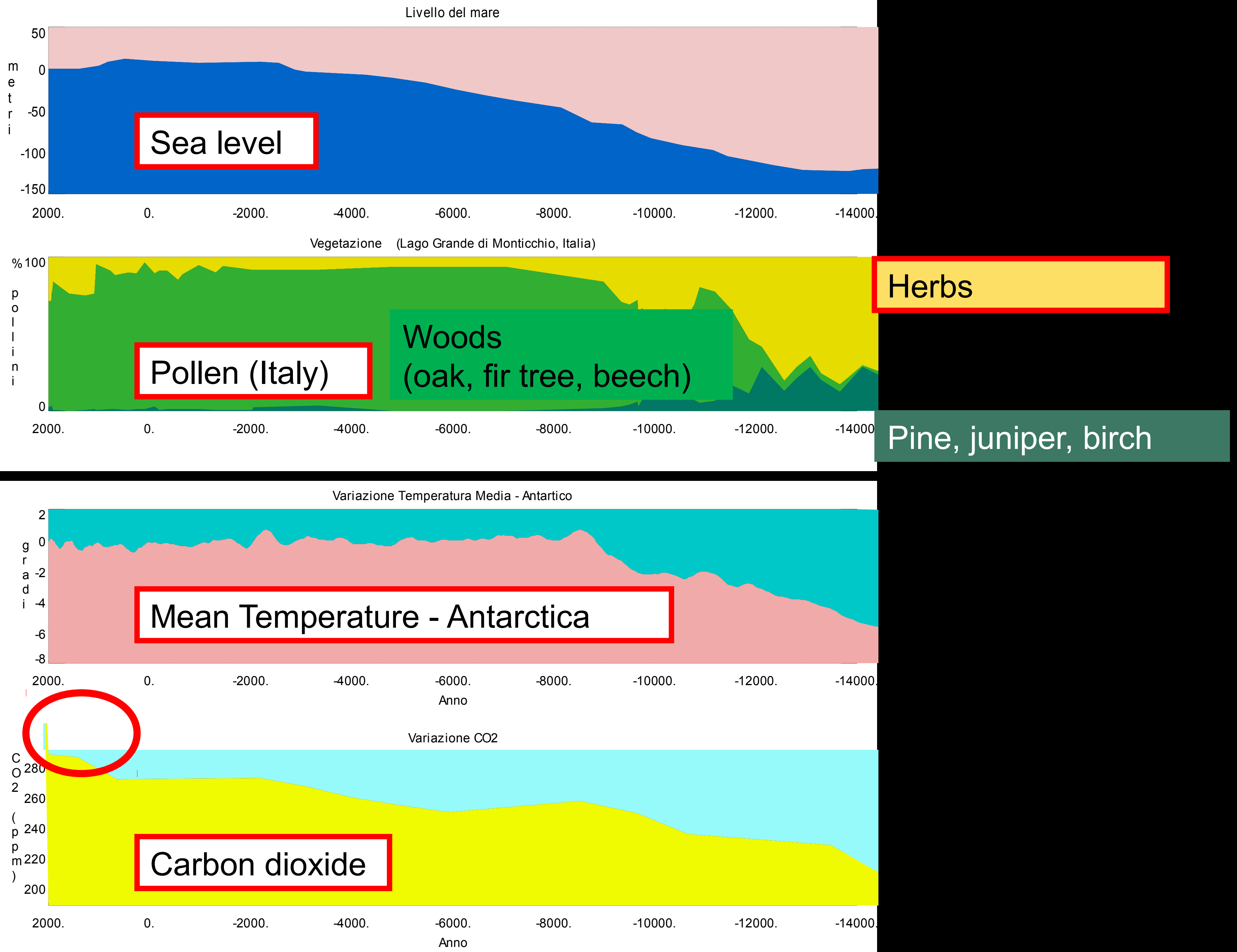
climate variation above background level. Non-periodic impacts and terrestrial mechanisms (volcanism, plate tectonics, sea level changes), possibly occurring simultaneously, remain likely causes of many environmental catastrophes. Internal dynamics of the biosphere may also play a role. In contrast, there is little evidence supporting the idea that cosmic rays have a significant influence on climate through cloud formation. It seems likely that more than one mechanism has contributed to biodiversity variations over the past half Gyr.

Received 15 April 2009, accepted 20 May 2009, first published online 14 July 2009

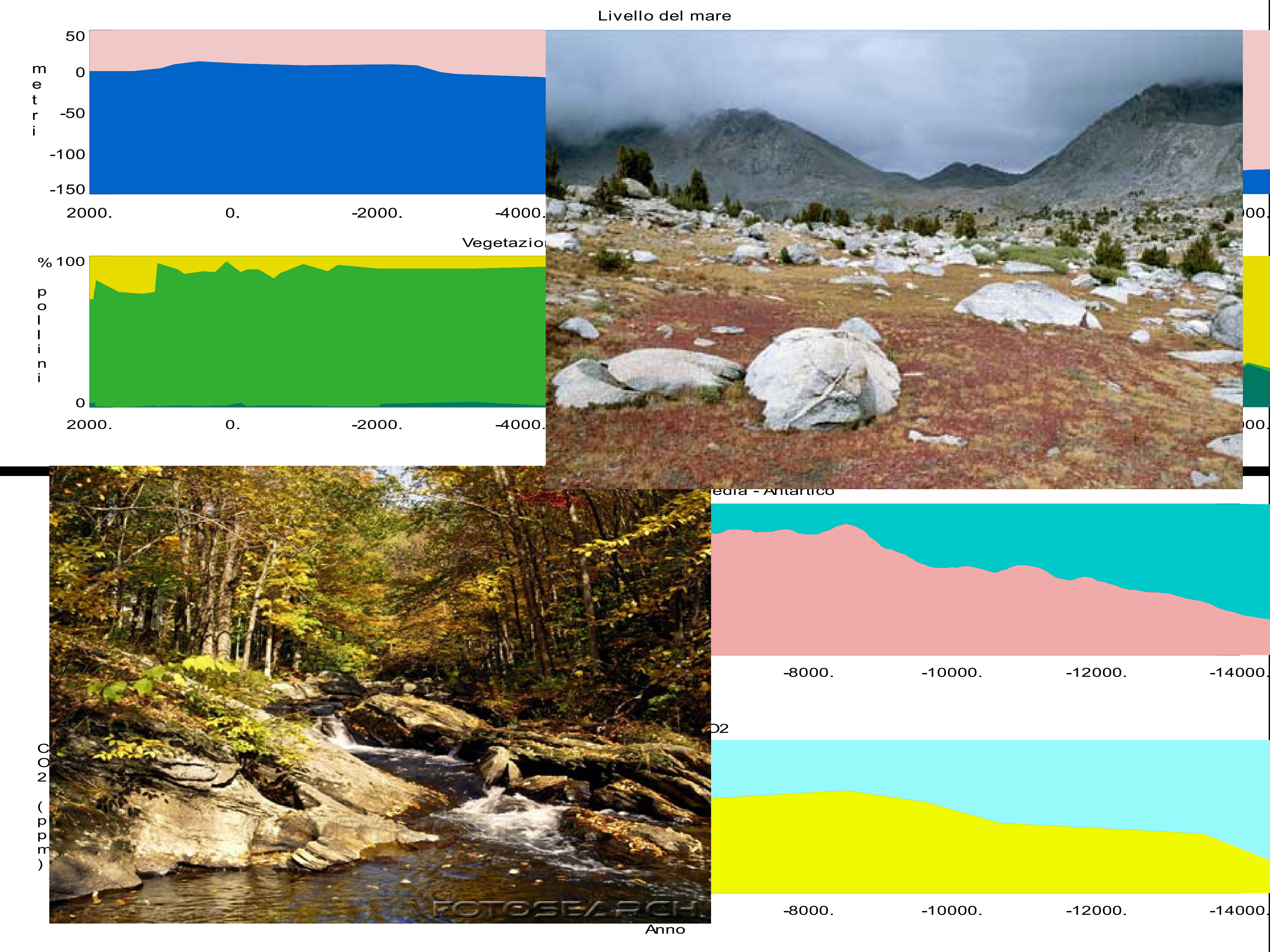
Key words: climate change, cosmic rays, hypothesis testing, mass extinctions, minor body impacts, period detection, solar motion, spiral arms, time series analysis.

Neolithic

Nevali Cori

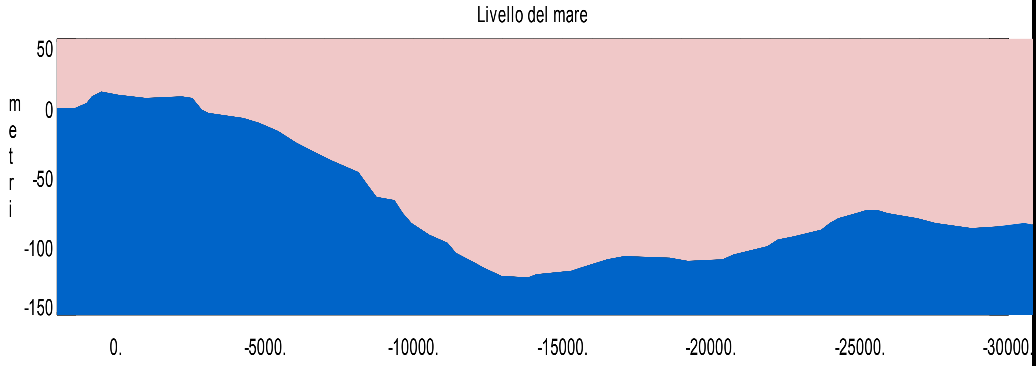


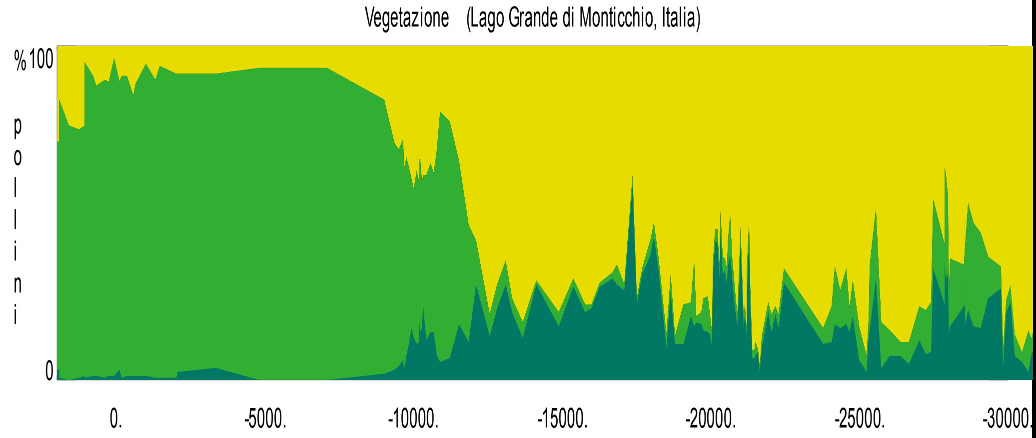
Livello del mare
metri
50
0
-50
-100
-150
Sea level
2000.
0.
-2000.
-4000.
-6000.
-8000.
-10000.
-12000.
-14000.
Vegetazione (Lago Grande di Monticchio, Italia)
% pollini
100
0
Herbs
Woods
(oak, fir tree, beech)
Pollen (Italy)
Pine, juniper, birch
Variazione Temperatura Media - Antartico
gradi
2
0
-2
-4
-6
-8
Mean Temperature - Antarctica
Anno
Variazione CO2
CO2 (ppm)
280
260
240
220
200
Carbon dioxide
Anno

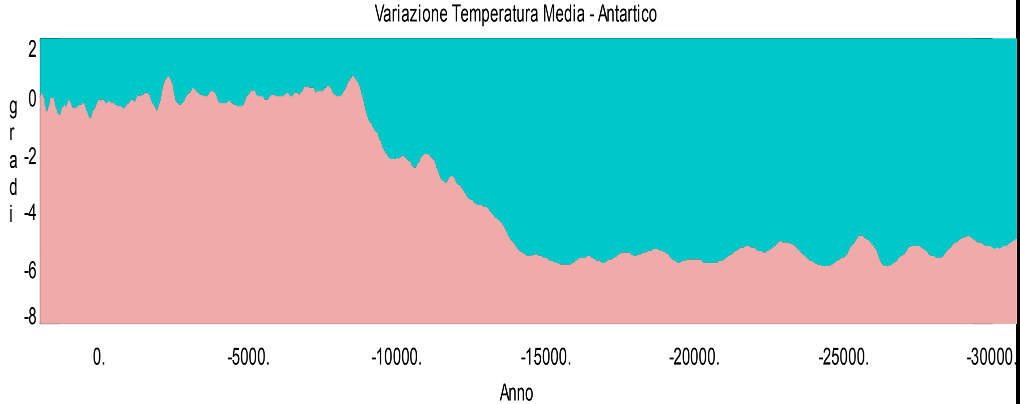


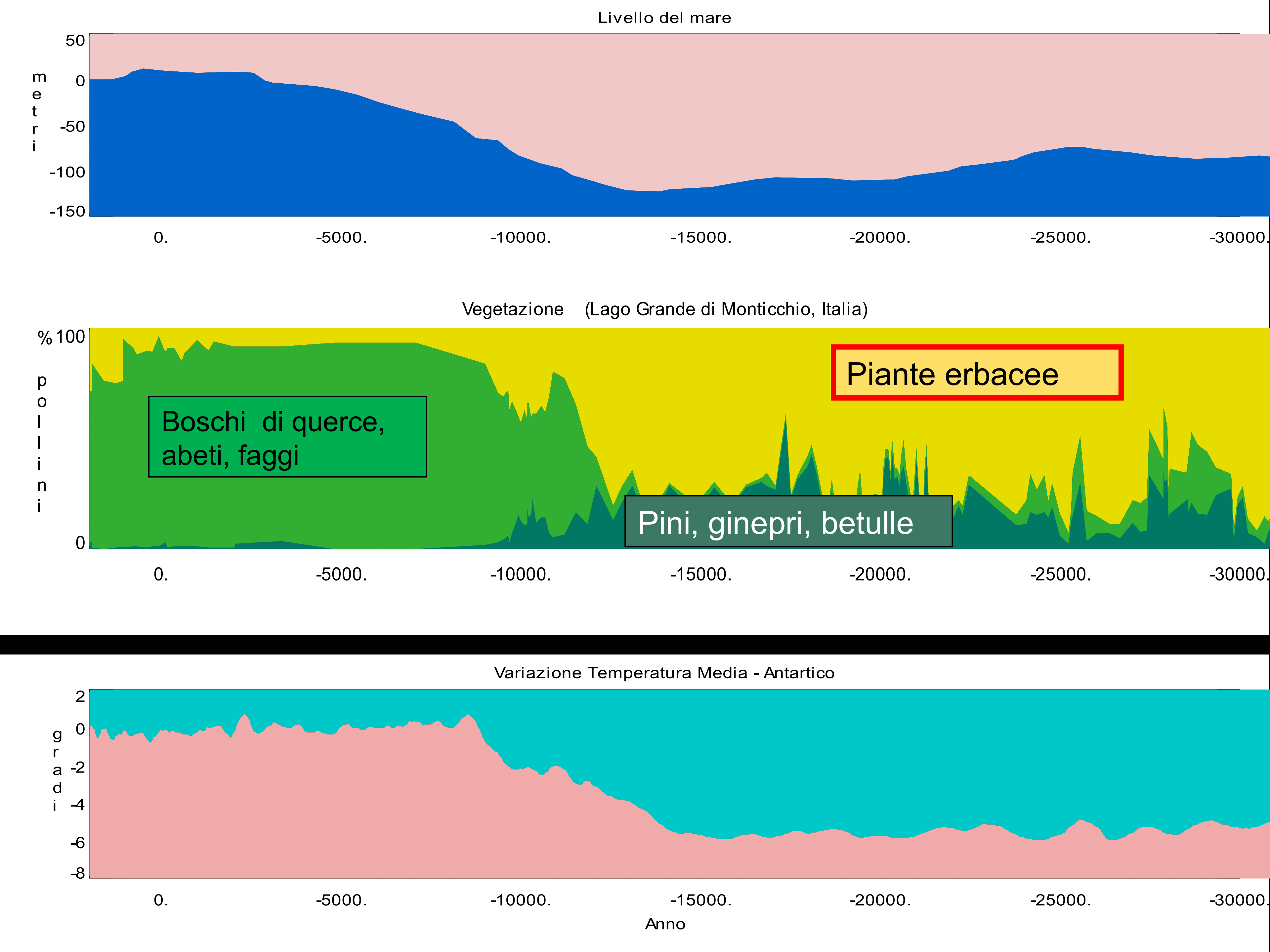
Livello del mare
metri
50
0
-50
-100
-150
2000.
0.
-2000.
-4000.
Vegetazio
% 100
pollini
0
2000.
0.
-2000.
-4000.
edia - Antartico
-8000.
-10000.
-12000.
-14000.
O2
CO2 (ppm)
-8000.
-10000.
-12000.
-14000.
Anno
FOTOSEARCH

Upper Palaeolithic > 14000 BC


Livello del mare
metri
50
0
-50
-100
-150
0.
-5000.
-10000.
-15000.
-20000.
-25000.
-30000.

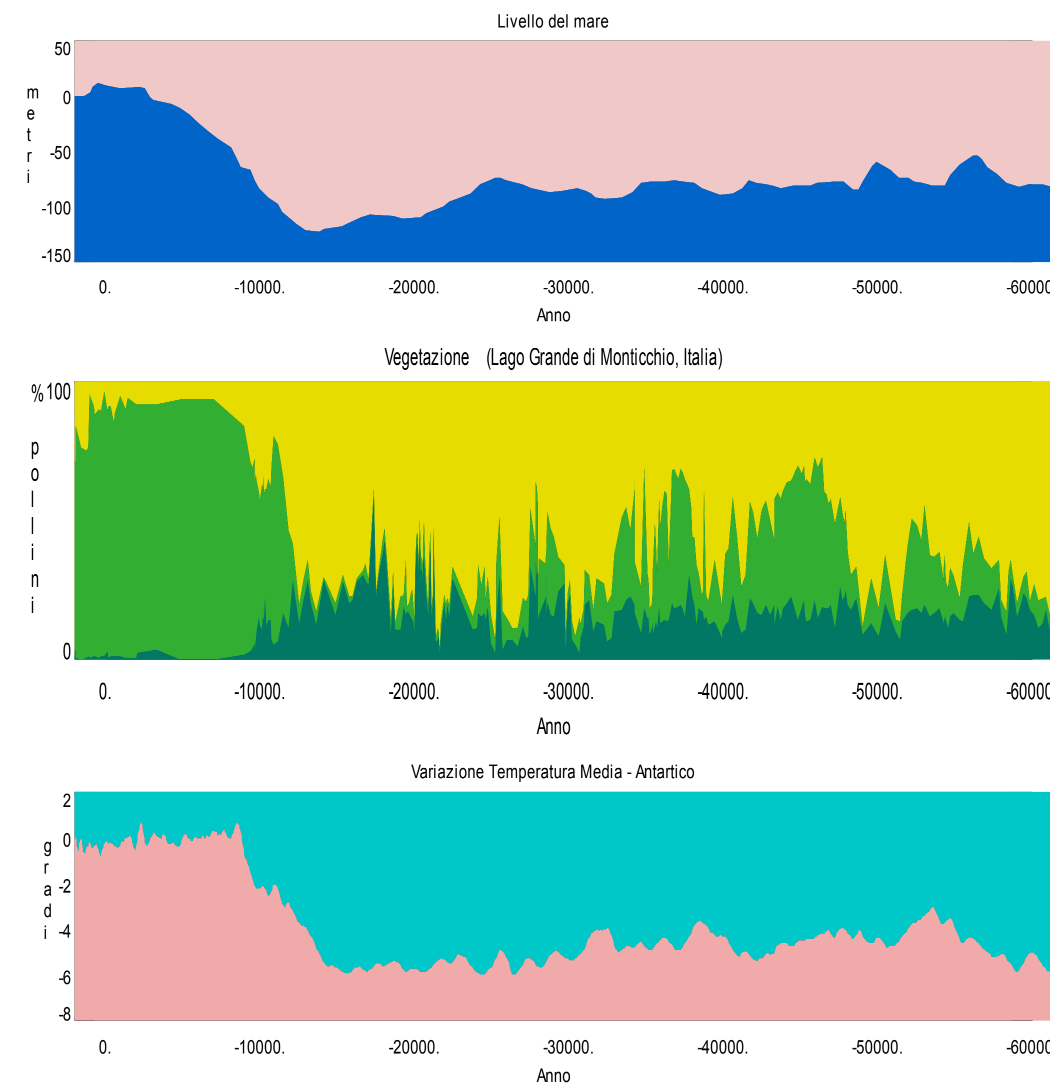

Vegetazione (Lago Grande di Monticchio, Italia)
% pollini
100
0
0.
-5000.
-10000.
-15000.
-20000.
-25000.
-30000.

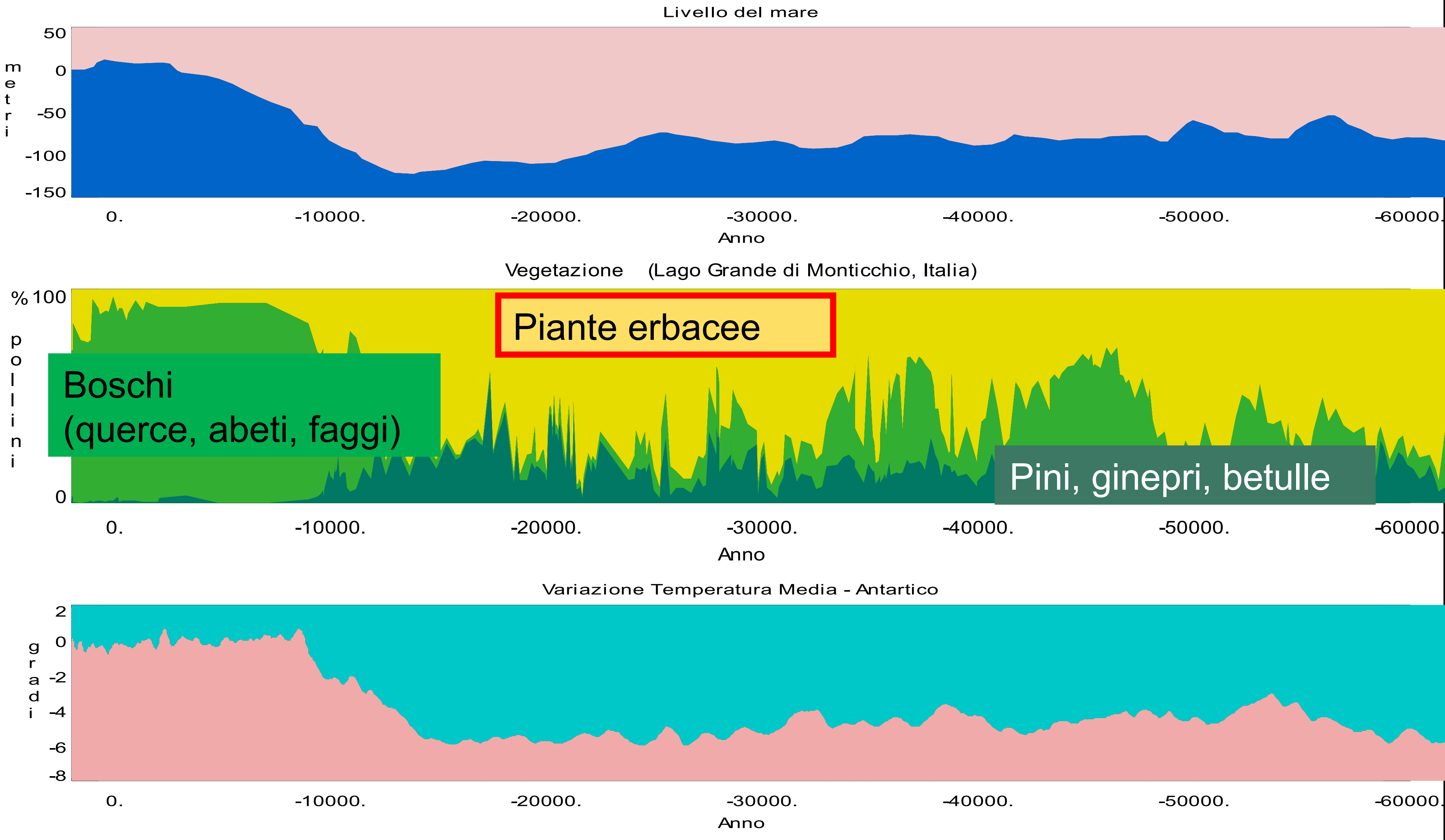

Variazione Temperatura Media - Antartico
gradi
2
0
-2
-4
-6
-8
0.
-5000.
-10000.
-15000.
-20000.
-25000.
-30000.
Anno


Livello del mare
metri
50
0
-50
-100
-150
0.
-5000.
-10000.
-15000.
-20000.
-25000.
-30000.
Vegetazione (Lago Grande di Monticchio, Italia)
% pollini
100
0
Piante erbacee
Boschi di querce, abeti, faggi
Pini, ginepri, betulle
0.
-5000.
-10000.
-15000.
-20000.
-25000.
-30000.
Variazione Temperatura Media - Antartico
gradi
2
0
-2
-4
-6
-8
0.
-5000.
-10000.
-15000.
-20000.
-25000.
-30000.
Anno

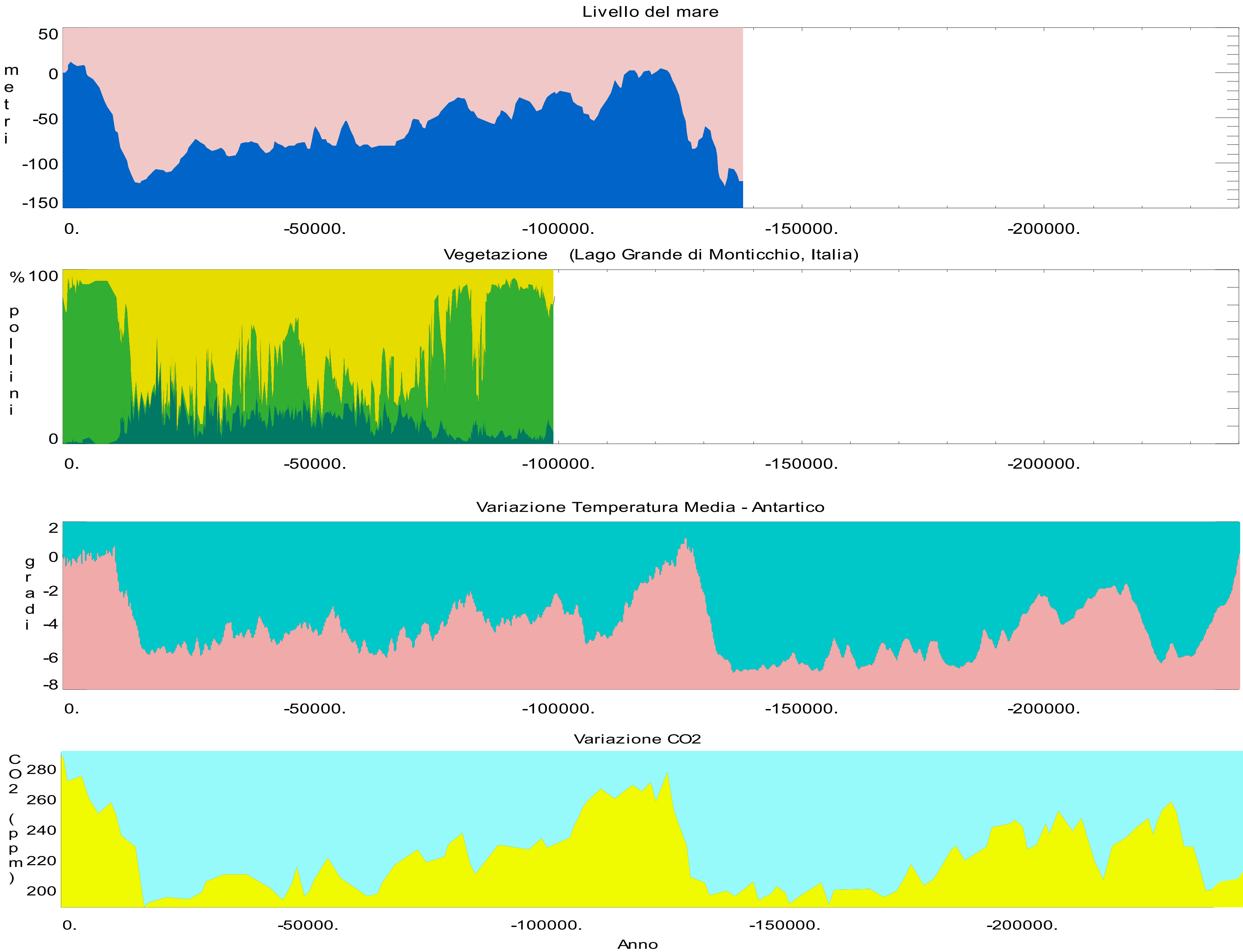
Middle Palaeolithic > 50000 BC

[Blombos Cave (South Africa) 75000 BC]


Livello del mare
metri
50
0
-50
-100
-150
0.
-10000.
-20000.
-30000.
-40000.
-50000.
-60000.
Anno
Vegetazione (Lago Grande di Monticchio, Italia)
% pollini
100
0
0.
-10000.
-20000.
-30000.
-40000.
-50000.
-60000.
Anno
Variazione Temperatura Media - Antartico
gradi
2
0
-2
-4
-6
-8
0.
-10000.
-20000.
-30000.
-40000.
-50000.
-60000.
Anno

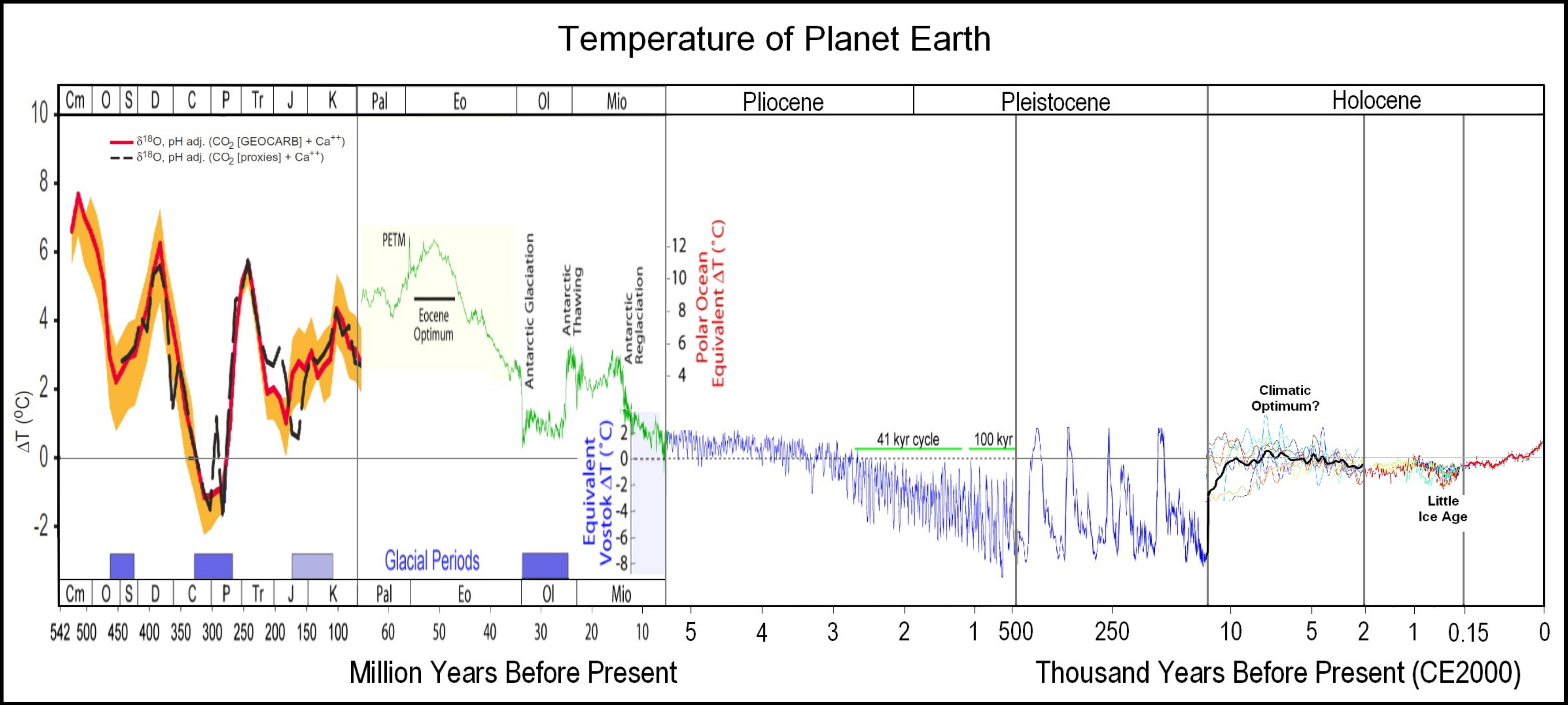


Livello del mare
50
0
-50
-100
-150
metri
0.
-10000.
-20000.
-30000.
-40000.
-50000.
-60000.
Anno
Vegetazione (Lago Grande di Monticchio, Italia)
% 100
0
pollini
Piante erbacee
Boschi
(querce, abeti, faggi)
Pini, ginepri, betulle
0.
-10000.
-20000.
-30000.
-40000.
-50000.
-60000.
Anno
Variazione Temperatura Media - Antartico
2
0
-2
-4
-6
-8
gradi
0.
-10000.
-20000.
-30000.
-40000.
-50000.
-60000.
Anno



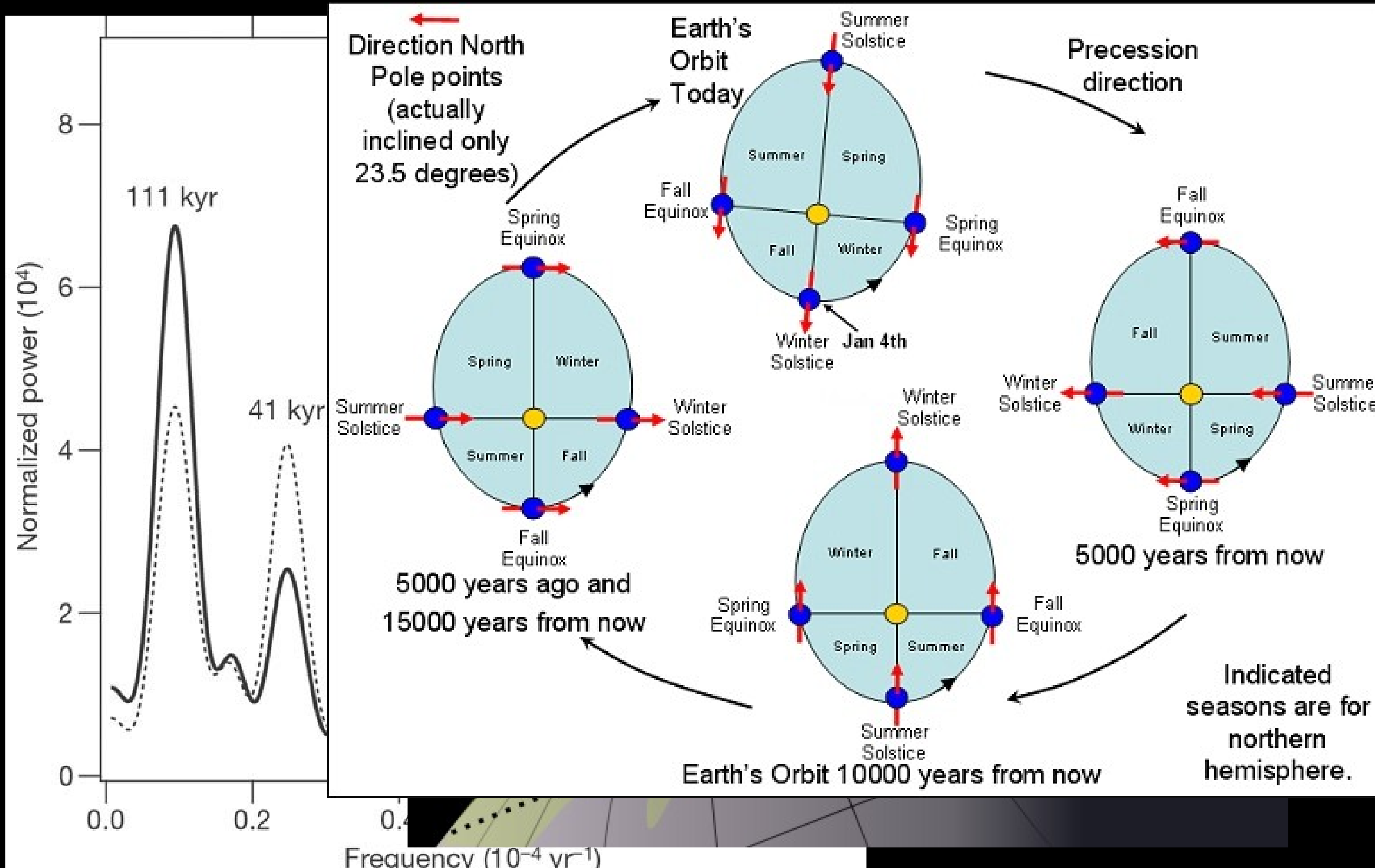
Livello del mare
metri
50
0
-50
-100
-150
0.
-50000.
-100000.
-150000.
-200000.
Vegetazione (Lago Grande di Monticchio, Italia)
% 100
pollini
0
0.
-50000.
-100000.
-150000.
-200000.
Variazione Temperatura Media - Antartico
gradi
2
0
-2
-4
-6
-8
0.
-50000.
-100000.
-150000.
-200000.
Variazione CO2
CO2 (ppm)
280
260
240
220
200
0.
-50000.
-100000.
-150000.
-200000.
Anno

Climate



Excess of Oxygen 18, δ18O

Oxygen isotopes: 16O 99.762 %
(in H2O…) 17O
0.038 %
18O 0.200



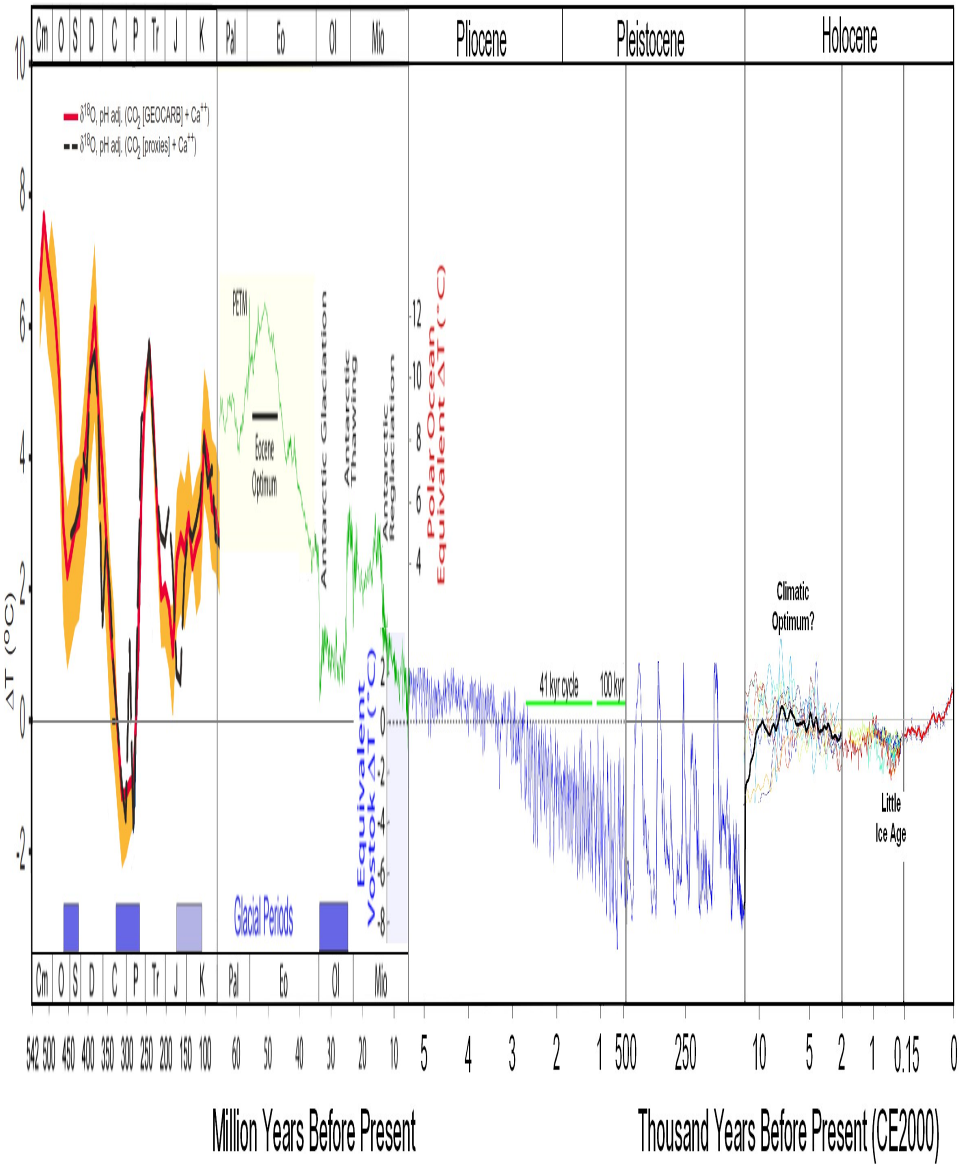
Link with astronomical cycles (**<u>Milankovitch</u>**):

110 000 years - excentricity of Earth orbit + ...

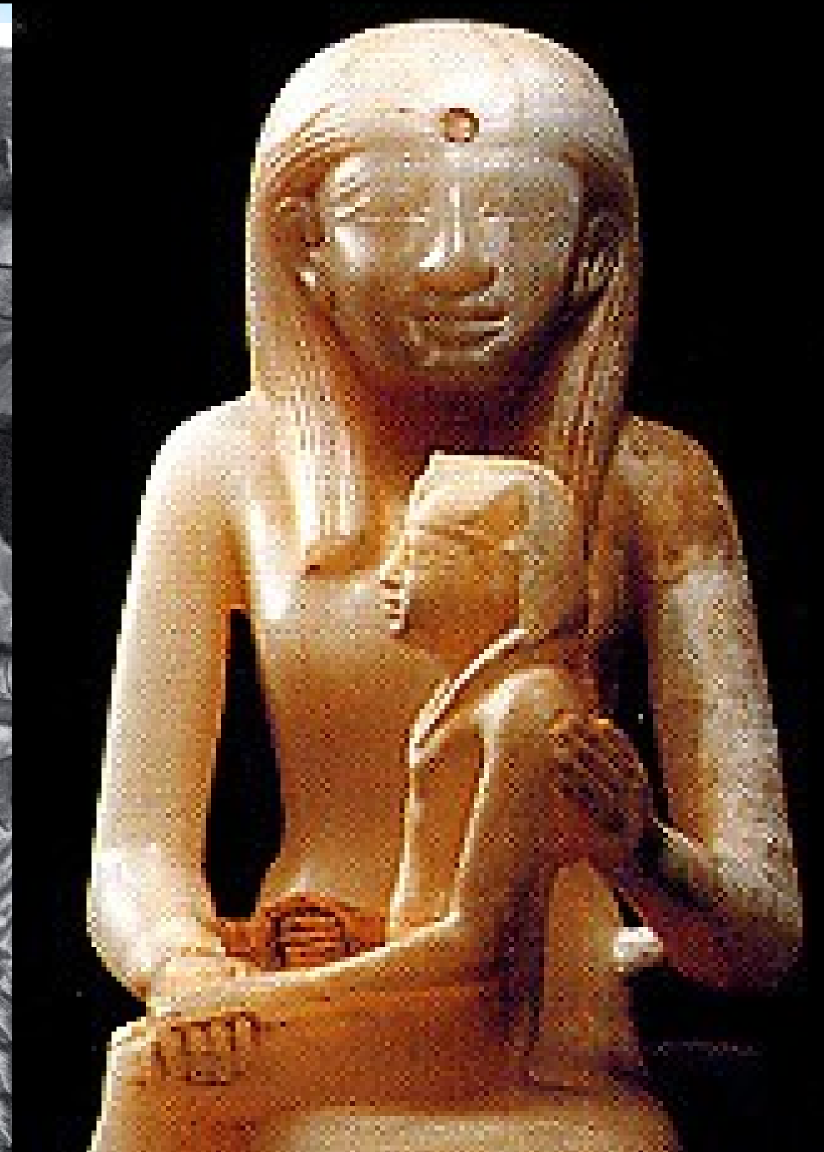
41 000 years - obliquity of ecliptic

23 000 years - seasonal precession (rotation of orbit on the plane)

Temperature of Planet Earth



Construction of canals during the sumeric epoch (2350 BC)



of

e

Akkadian E
Neolithic civ
have also in g
within the H

Possible ca ges related to
solar activity

The understanding of the history of the Earth, of the evolution of the life on Earth, of the mankind, of the human thought and of civilization cannot leave out the effects of astronomical/cosmic phenomena, since they triggered, are triggering and will trigger the most important changes in such an history.

Brera Obs. - Schedule/planning

2010 – G.V. Schiaparelli, 100th anniv.

(Schiaparelli and his legacy, G. Trinchieri & A. Manara eds.,

Mem. SAIt 82, 2011)

2011 – R.G. Boscovich, 300th anniv.

(Ruggiero Boscovich-uomo di scienza e di cultura, 18 may 2011)

2012 – Beginning of the professional astronomical research in Milan (250th anniv.; *meeting*); 50th anniv. of the first cosmic X-ray observation *(international meeting)*

2013 – Beginning of the meteorological observations in Brera, 250th anniv.

(international meeting on climate; collab. with UniMi)

2014 – The Brera Observatory (project), 250th anniv.

(meeting in collaboration with the Biblioteca Ambrosiana)

2015 – The foundation of the Brera Observatory, 250th anniv.

(EXPO 2015 – Astronomy and climate)