How variations in the rates of effusive basaltic flood volcanism versus aerosol-forming explosive volcanism have driven climate change and rates of mass extinction throughout Earth history

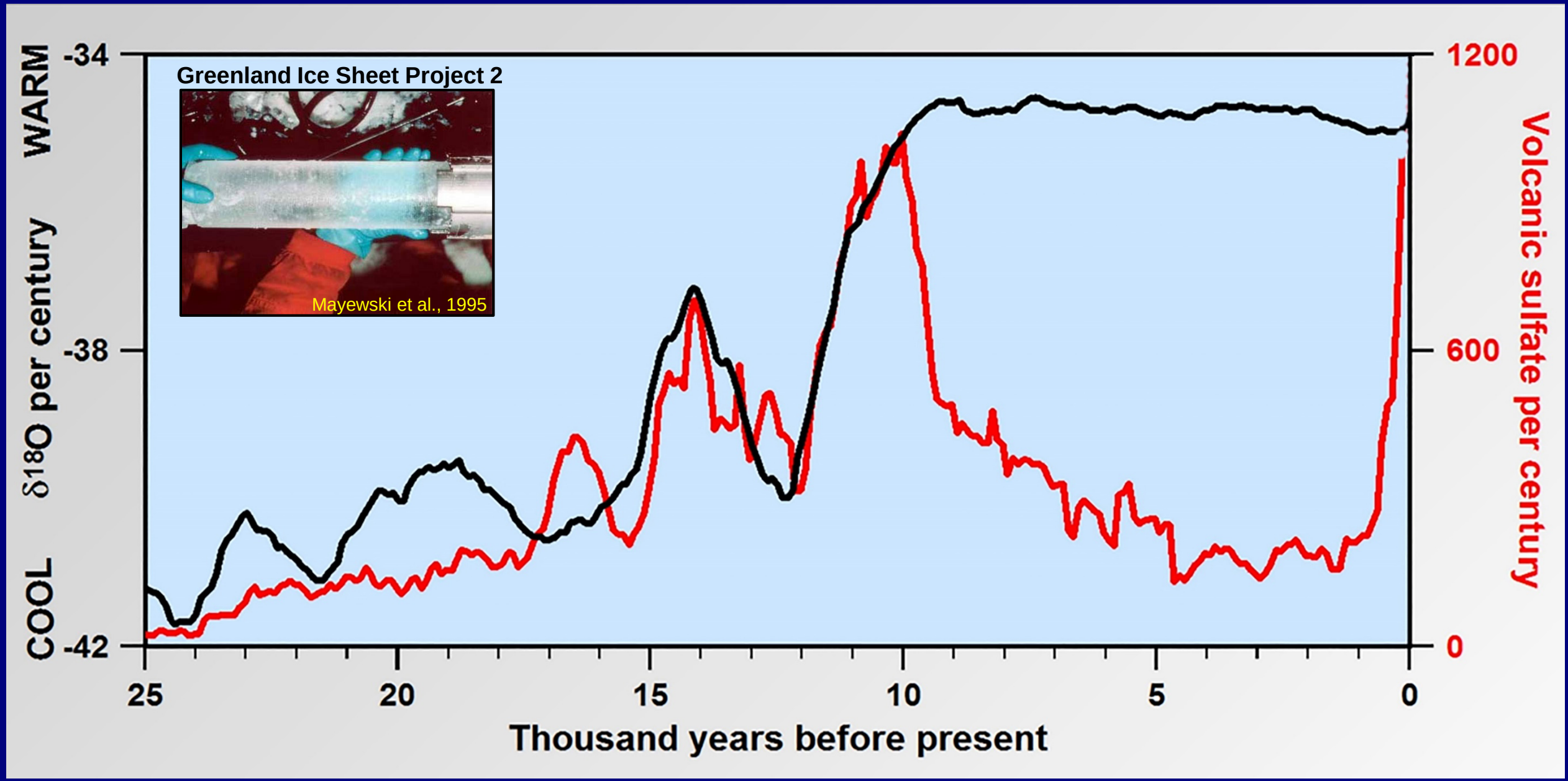
Peter L. Ward

United States Geological Survey retired

peward@Wyoming.com

USGS

Basaltic volcanism warmed the world out of the last ice age



Zielinski et al., 1996

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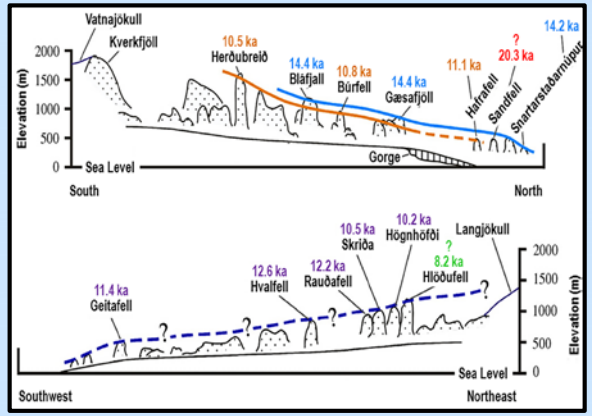


Licciardi et al., 2007

WARM

COOL

$\delta^{18}O$ per century

-34

-38

-42

1200

600

0

Volcanic sulfate per century

25

20

15

10

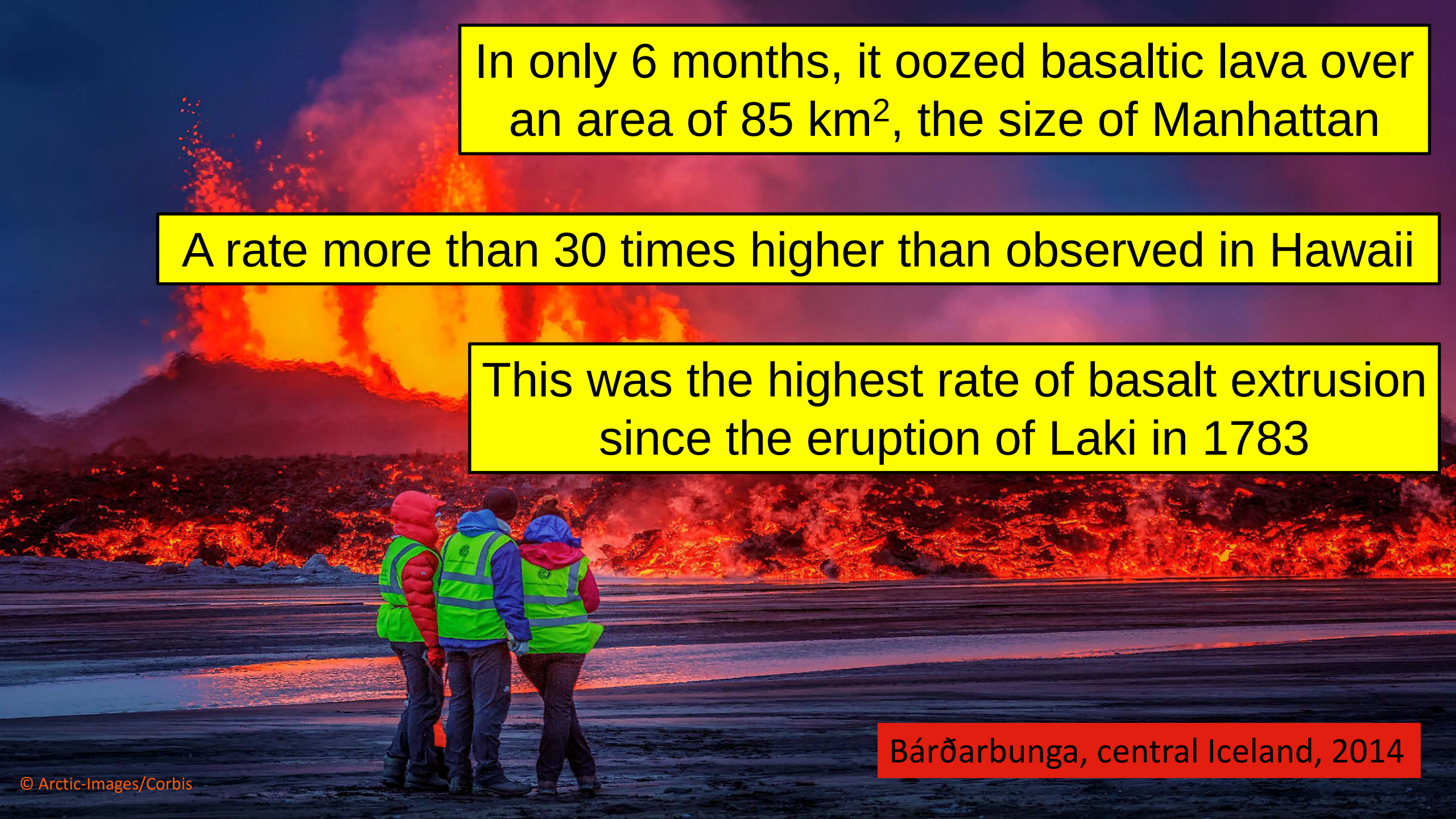
5

0

Thousand years before present

Zielinski et al., 1996

Bárðarbunga, central Iceland, 2014


In only 6 months, it oozed basaltic lava over an area of 85 km^2, the size of Manhattan
A rate more than 30 times higher than observed in Hawaii
This was the highest rate of basalt extrusion since the eruption of Laki in 1783
Bárðarbunga, central Iceland, 2014
© Arctic-Images/Corbis

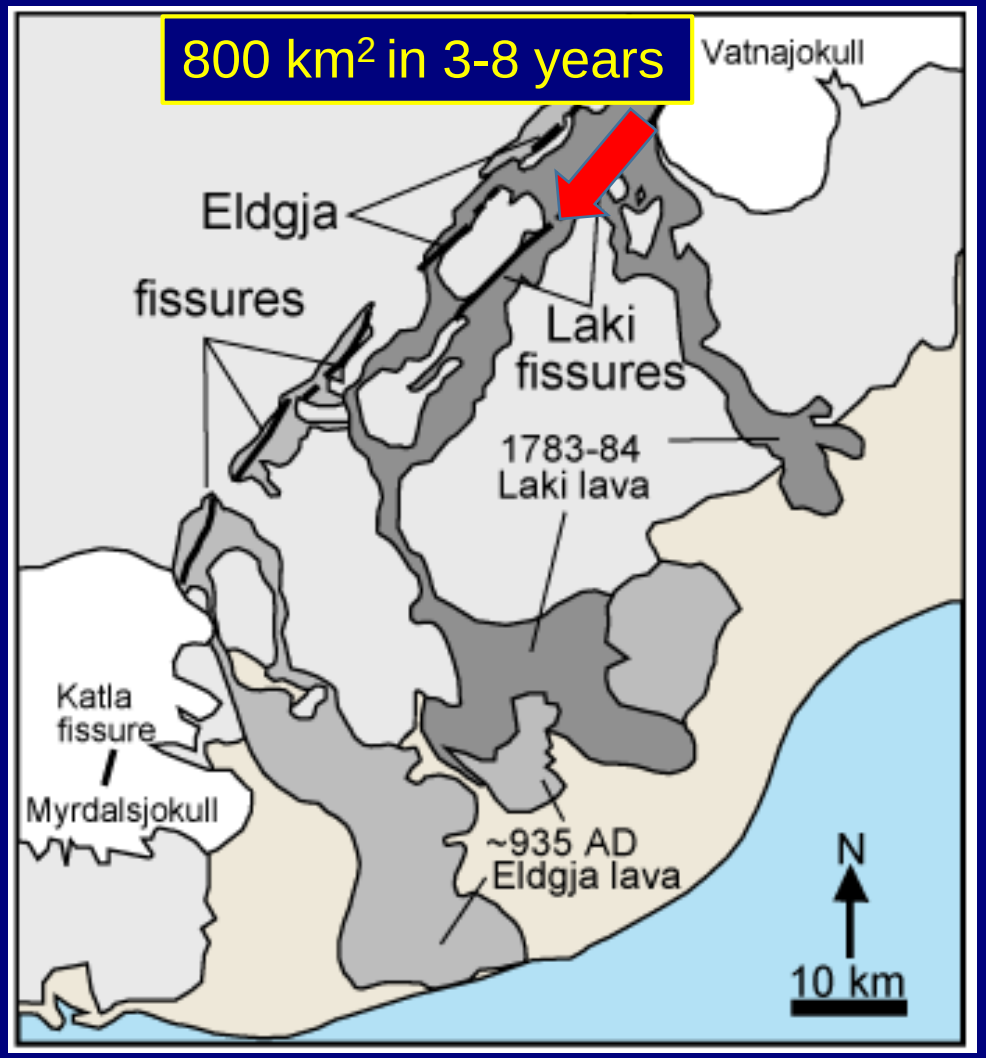
Laki 1783

Temperatures raised 3.3^{o}C, tens of thousands killed primarily by the effects of sulfuric acid

Laki 1783

Temperatures raised 3.3ºC, tens of thousands killed primarily by the effects of sulfuric acid

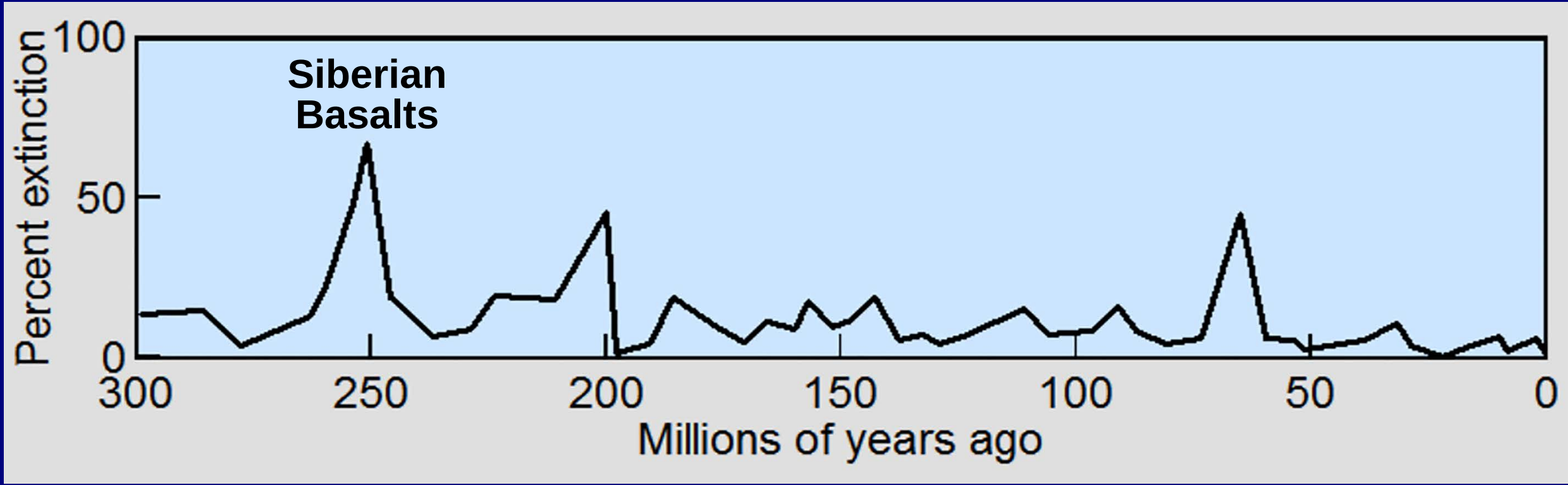
Eldgjá 935



volcano.oregonstate.edu

Led to the onset of the Medieval Warm Period


Arctic Ocean
Finland
Санкт-Петербург
Moscow
Волгоград
Caspian Sea
Sea of Okhotsk
Якутск
Lake Baikal
Siberian Basalts
7,000,000 km²


Siberian Basalts
Percent extinction
100
50
0
300
250
200
150
100
50
0
Millions of years ago


Arctic Ocean
Finland
Санкт-Петербург
Moscow
Волгоград
Caspian Sea
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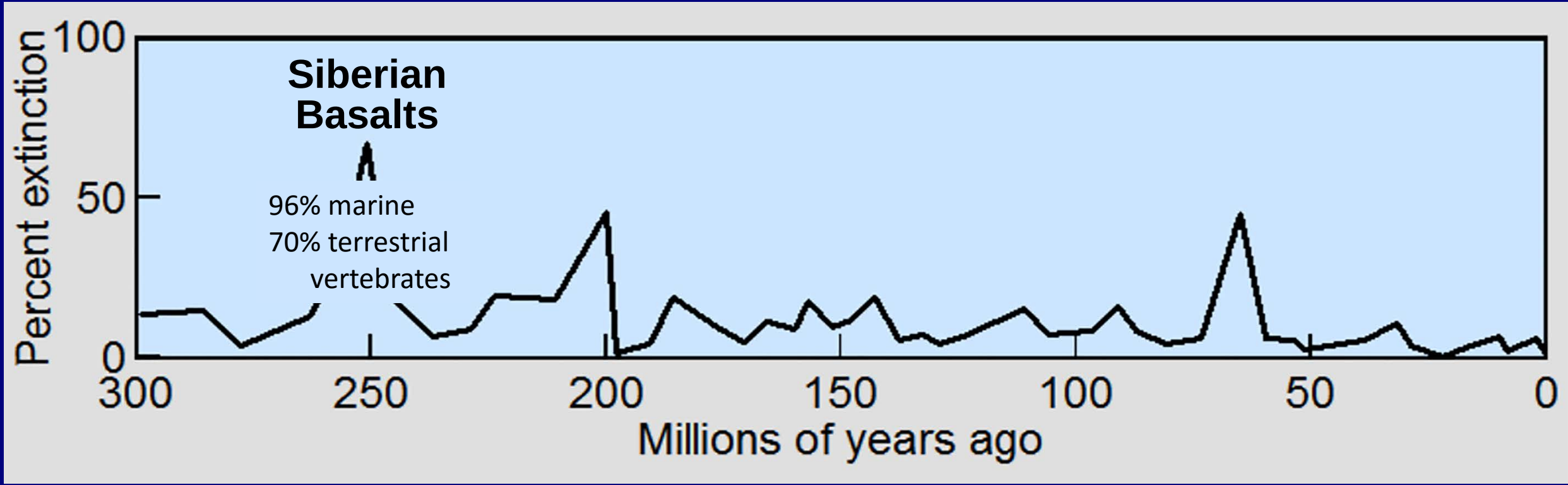
7,000,000 km²


Siberian Basalts
96% marine
70% terrestrial vertebrates
Percent extinction
100
50
0
300
250
200
150
100
50
0
Millions of years ago


Arctic Ocean
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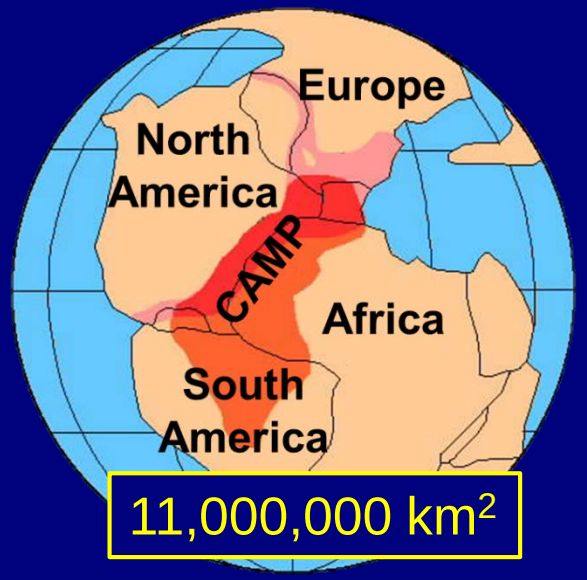
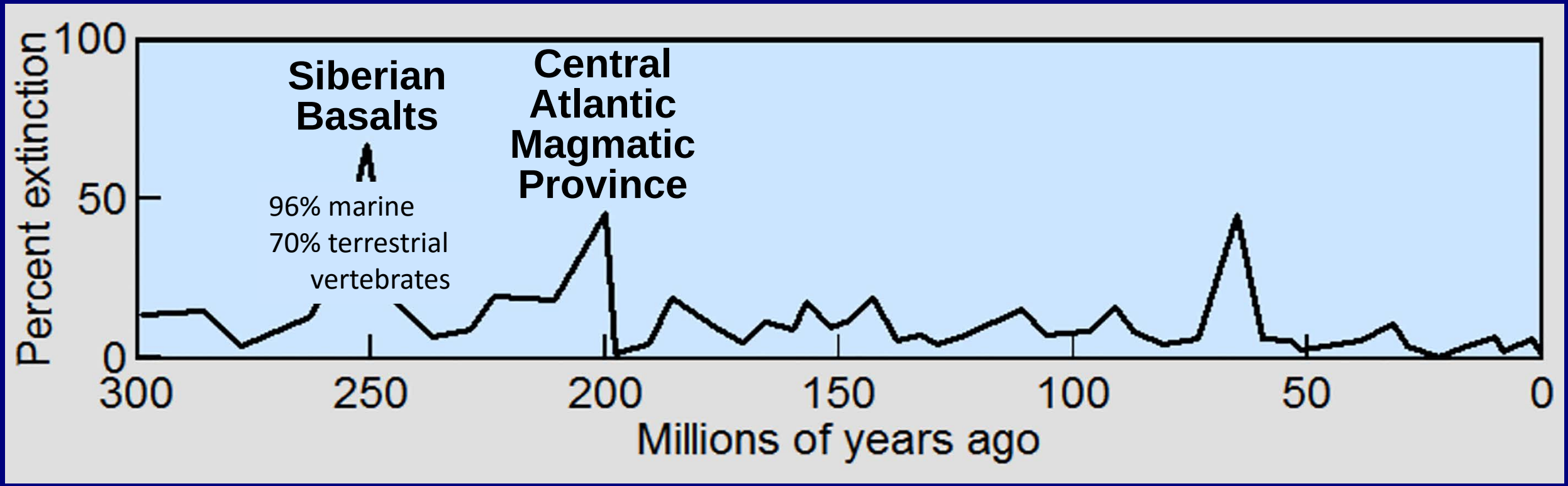

Europe
North America
CAMP
Africa
South America
11,000,000 km²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Central Atlantic Magmatic Province
300
250
200
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Millions of years ago


Arctic Ocean
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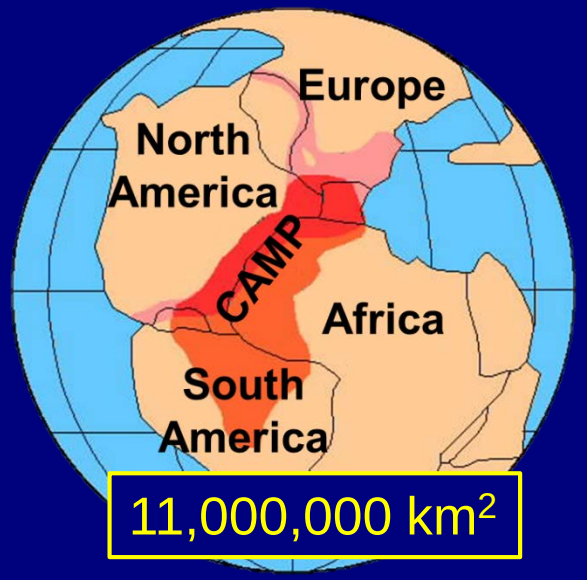
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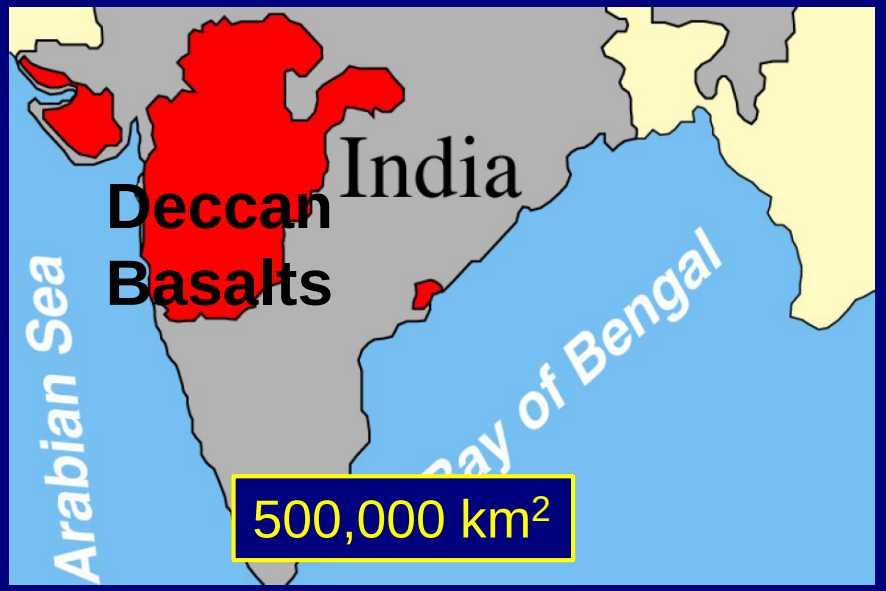
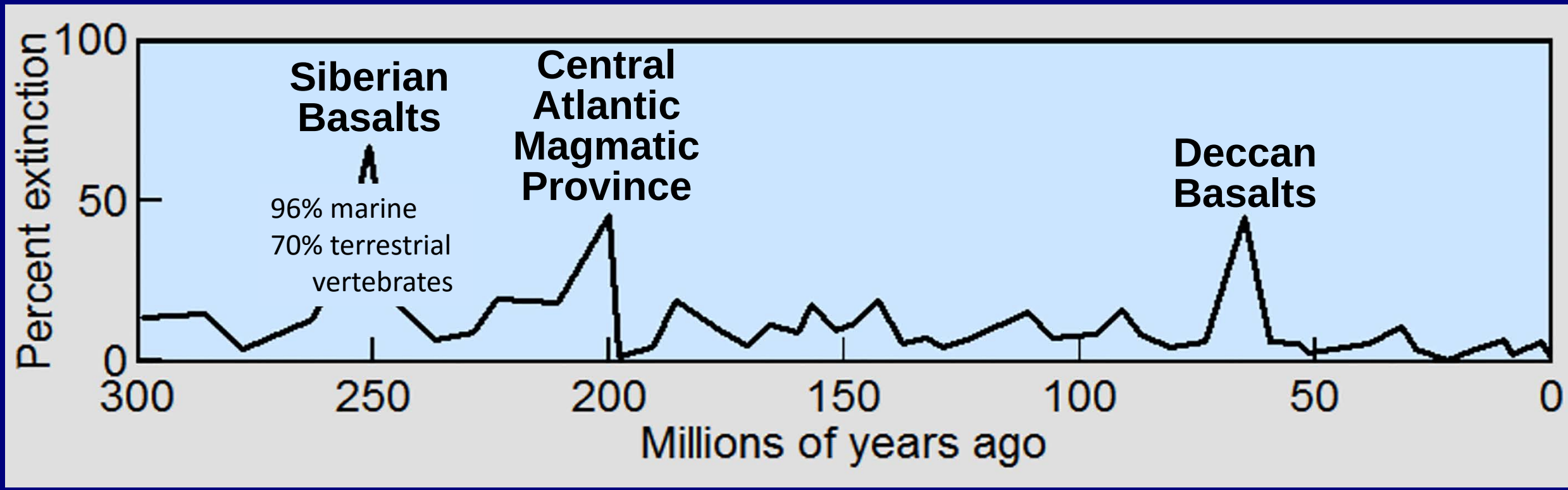

India
Deccan Basalts
Arabian Sea
Bay of Bengal
500,000 km²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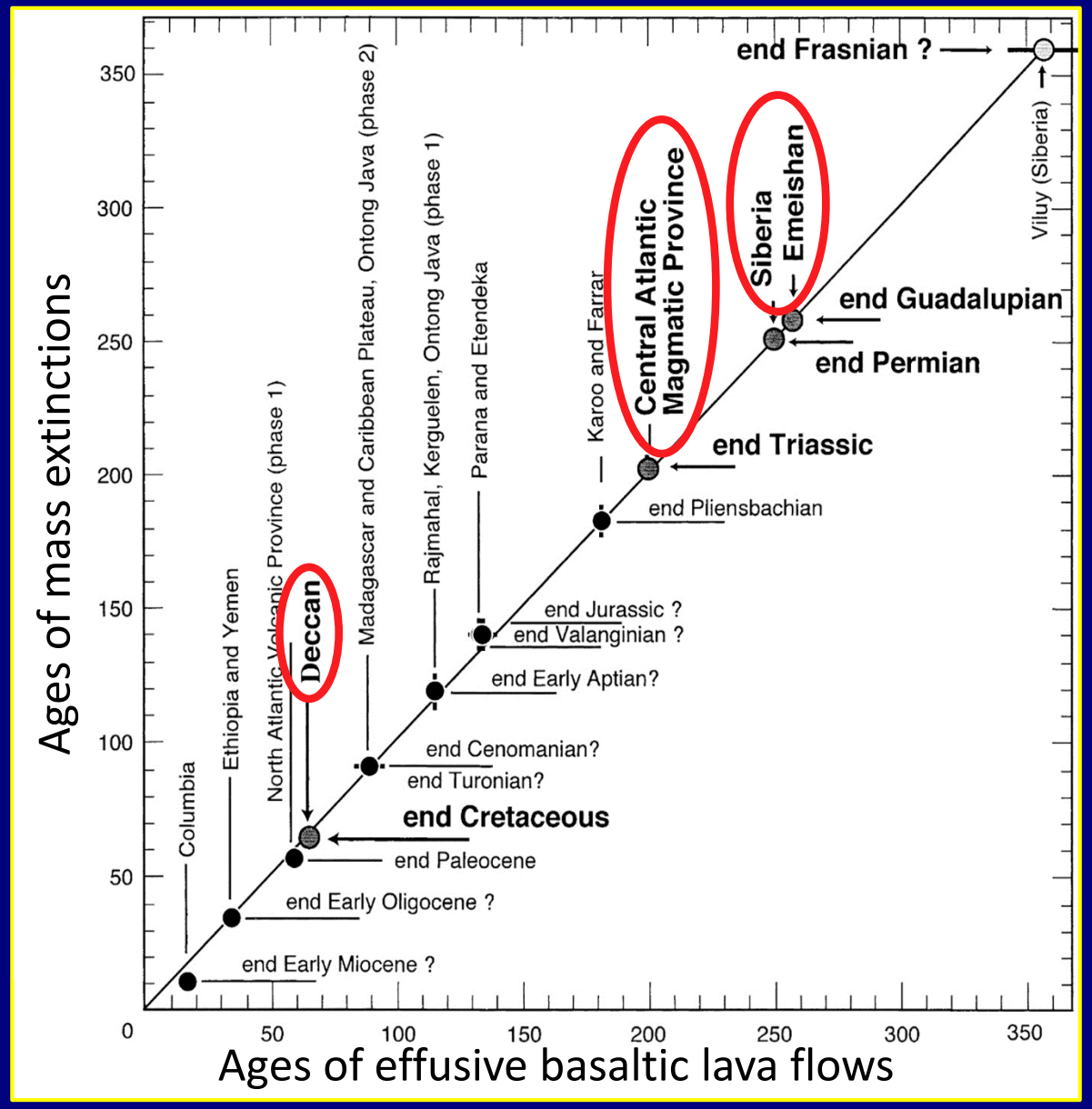
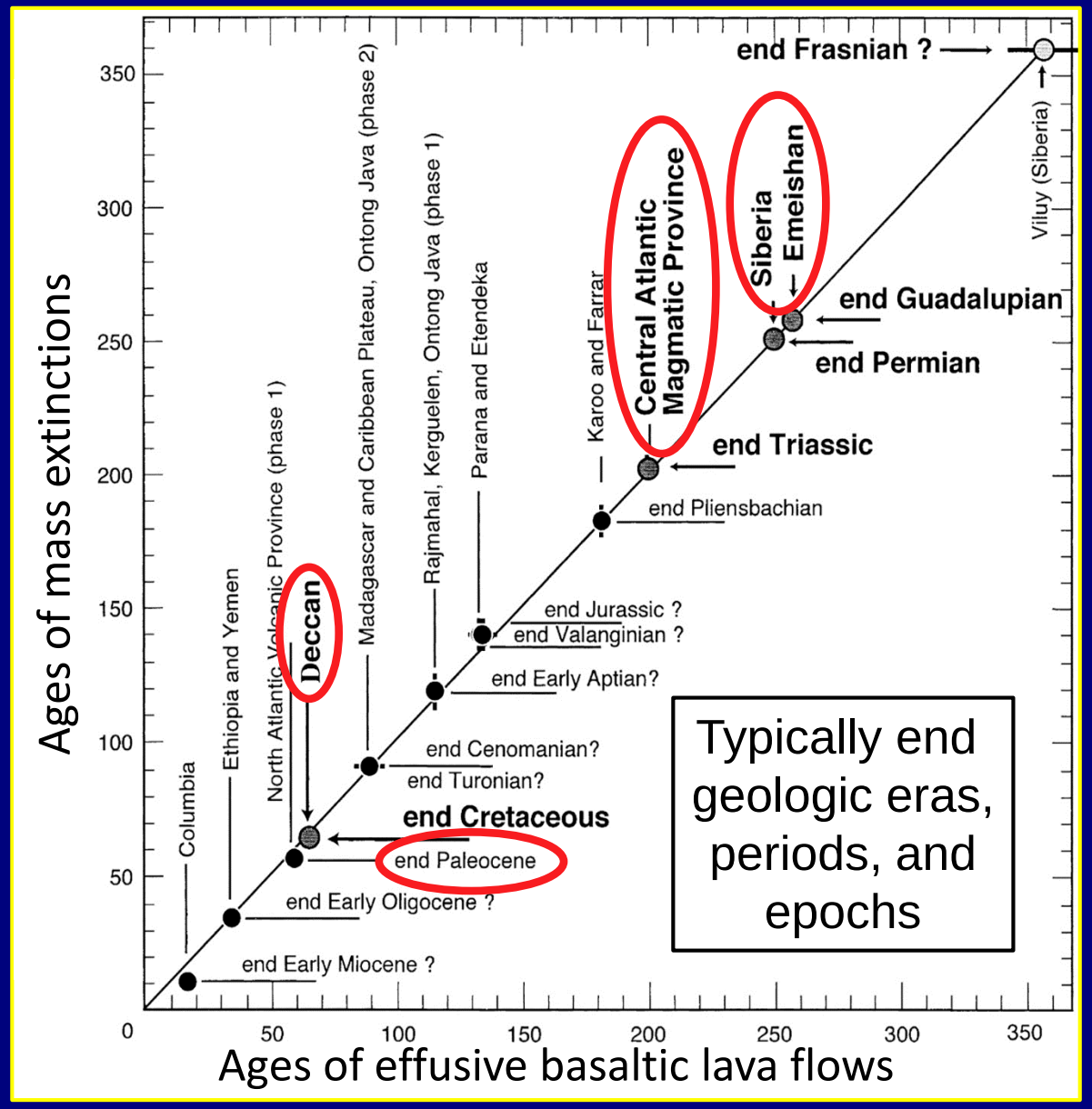
Mass extinctions versus flood basalts



Courtillot and Renne 2003

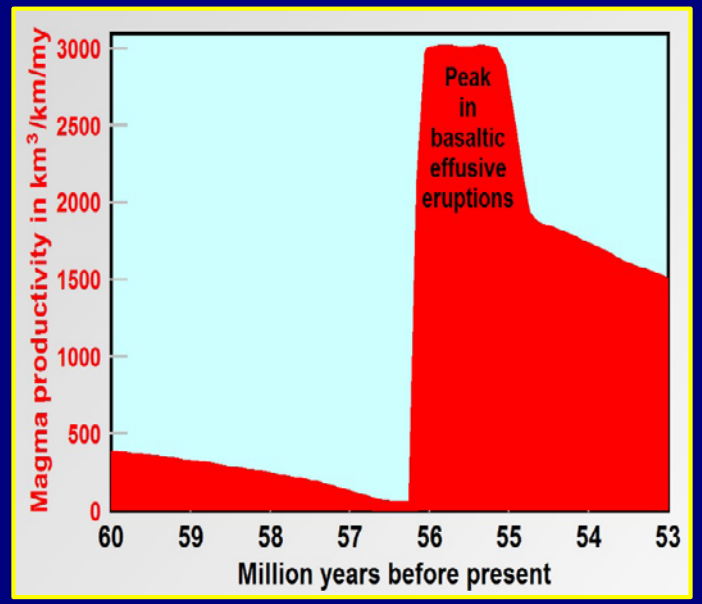
Mass extinctions versus flood basalts

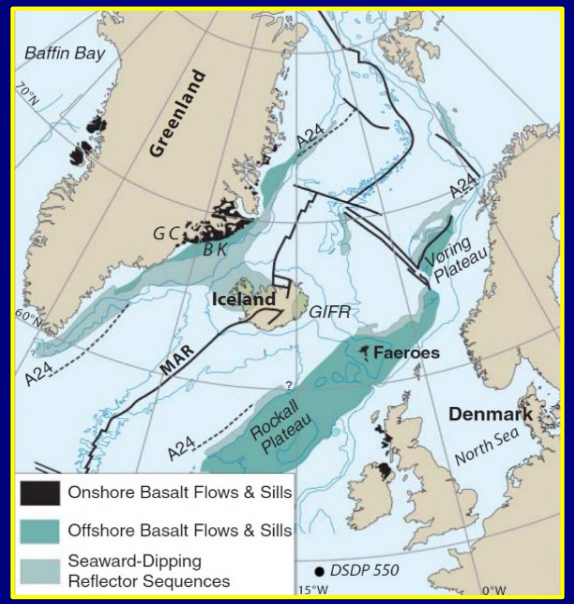


Courtillot and Renne 2003

Paleocene Eocene Thermal Maximum

Extrusion of basaltic magma reached a peak 56 million years ago during the rifting of the Greenland-Norwegian Sea





Storey et al. 2007

Rift-related, effusive, basaltic, volcanic eruptions warm Earth suddenly

Extrude basaltic lava for months to hundreds of thousands of years

The greater the duration, the greater the warming and extinctions

Range in size from Hawaii to Large Igneous Provinces

Cause major warming of air and, over millennia, of oceans

Cause major ocean acidity (sulfuric acid from SO_2 and H_2S)

Cause major mass extinctions especially when lasting for long periods

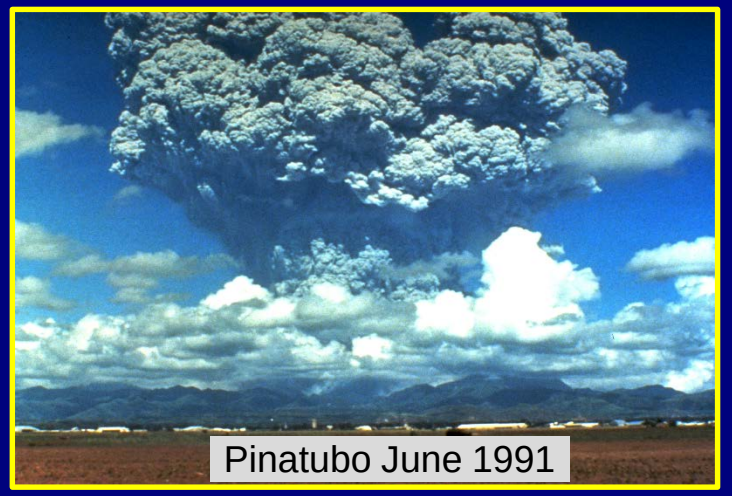
Bárðarbunga largest since 1783—explains why 2016 hottest year

A fundamentally different type of volcanic eruption

Subduction-related, explosive, volcanic eruptions cool Earth incrementally over centuries

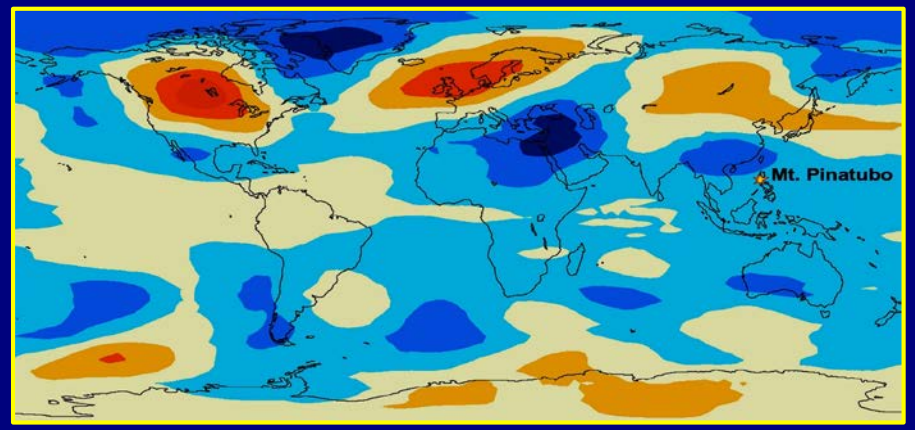
Erupt for days, may recur within 500 to 1000 years

Deplete ozone causing short-term warming



USGS

Pinatubo warmed 3.5°C
Dec 1991 to Feb 1992



Robock, 2002

A fundamentally different type of volcanic eruption

Subduction-related, explosive, volcanic eruptions cool Earth incrementally over centuries

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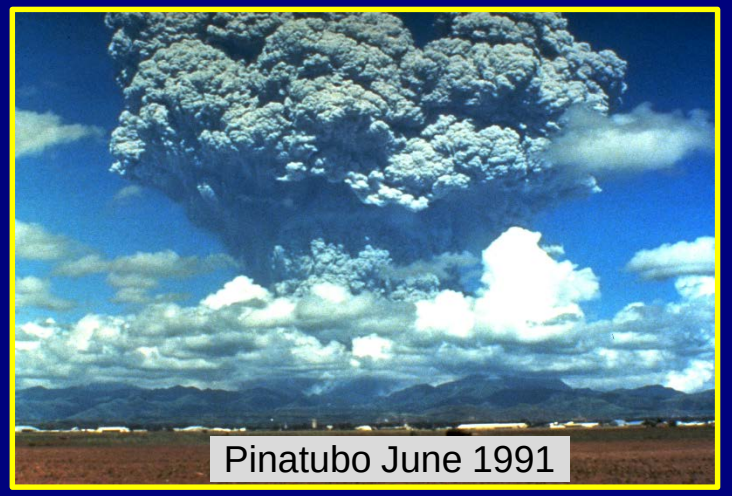
Deplete ozone causing short-term warming

Form aerosols in the lower stratosphere that last for years, scattering and reflecting solar energy, causing net global cooling 0.5^{o}C, 3 years


Pinatubo June 1991

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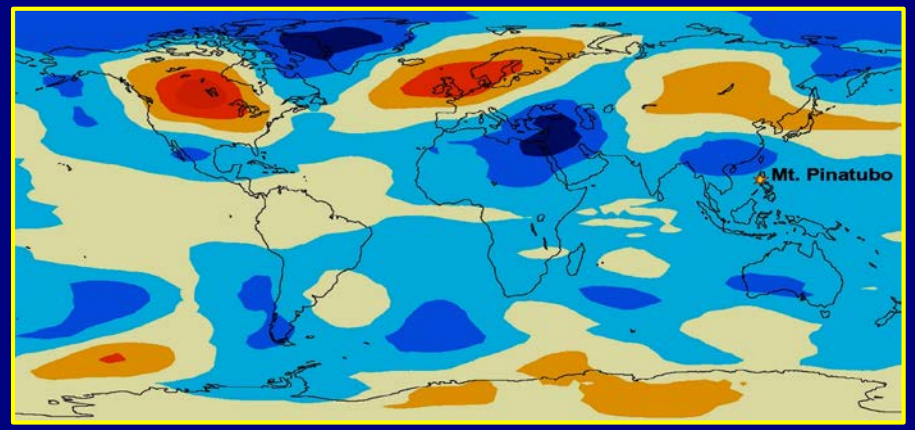

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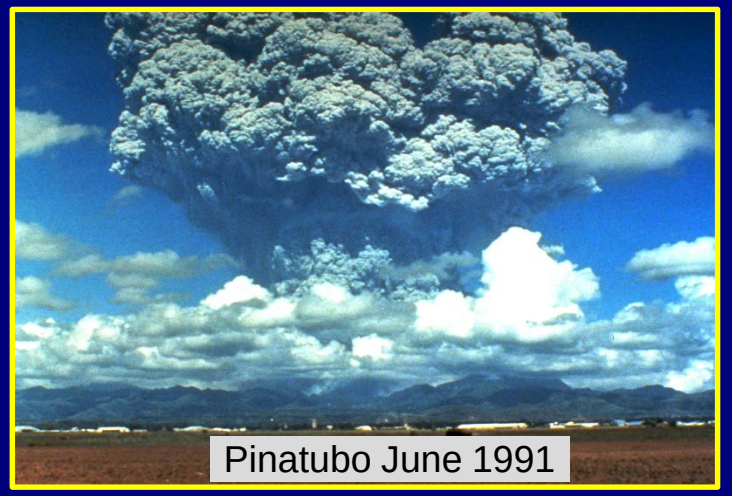

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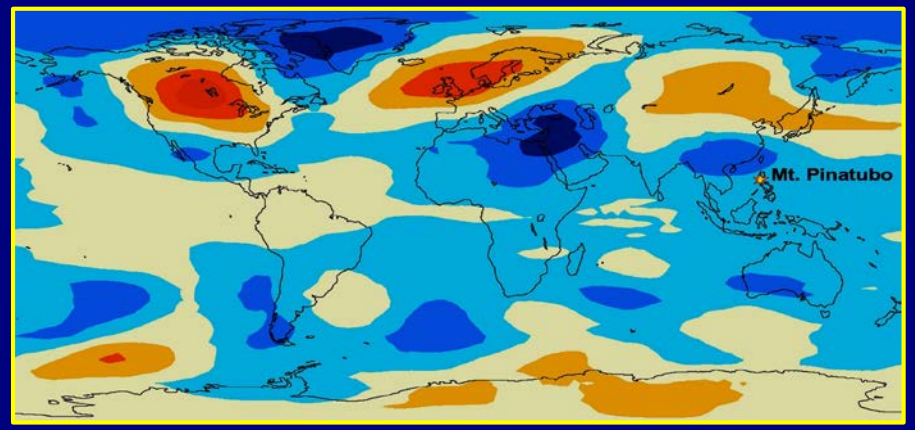
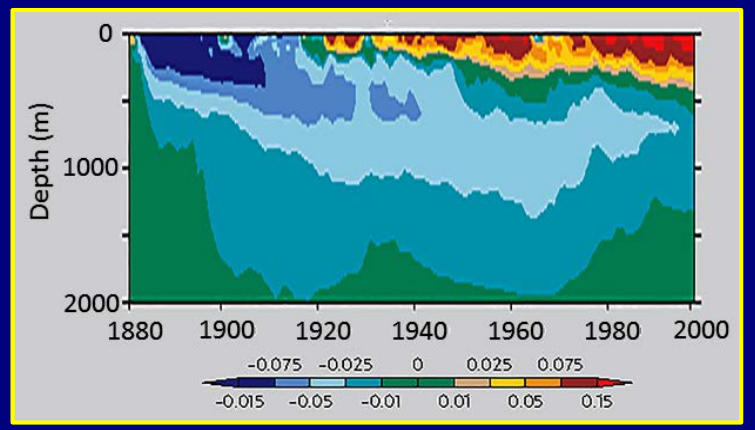


Robock, 2002

Krakatau (1883) cooled ocean for more than 100 years



Gleckler et al., 2006

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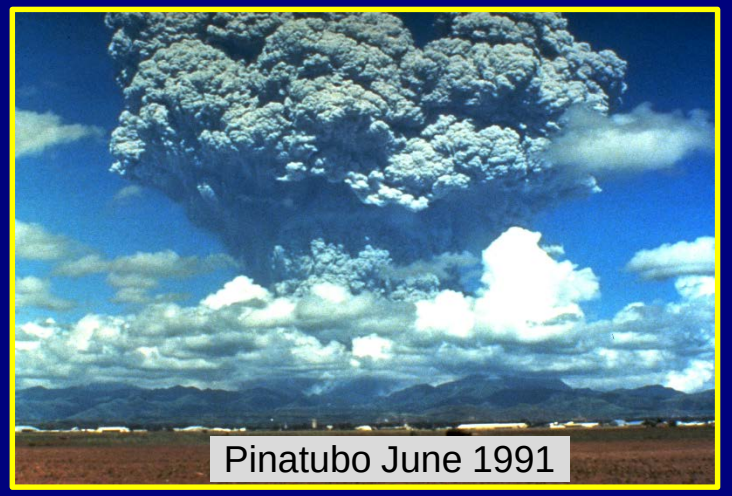

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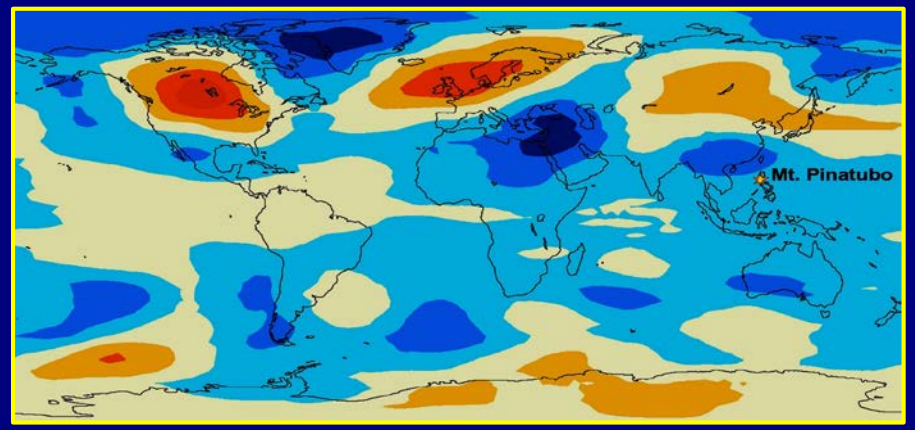

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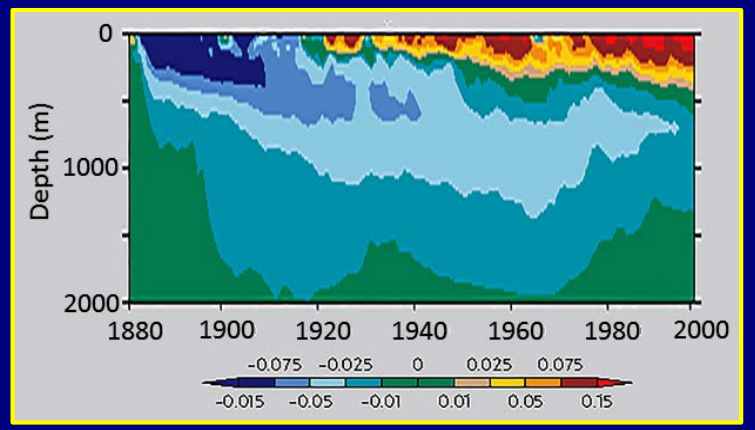
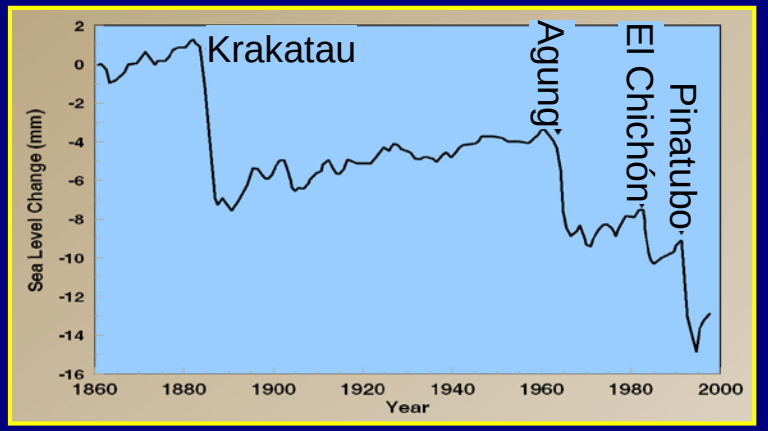


Gleckler et al., 2006

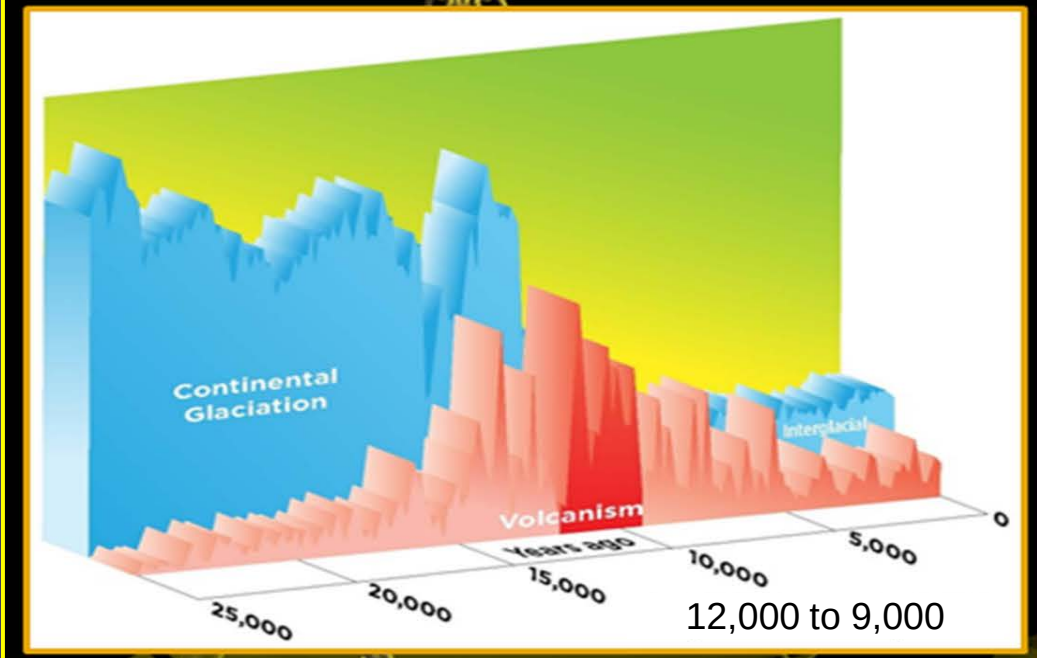
Multiple eruptions increment world into an ice age



Gregory et al., 2006

Rapid global warming
rift-related

Slow global cooling
subduction-related



12,000 to 9,000

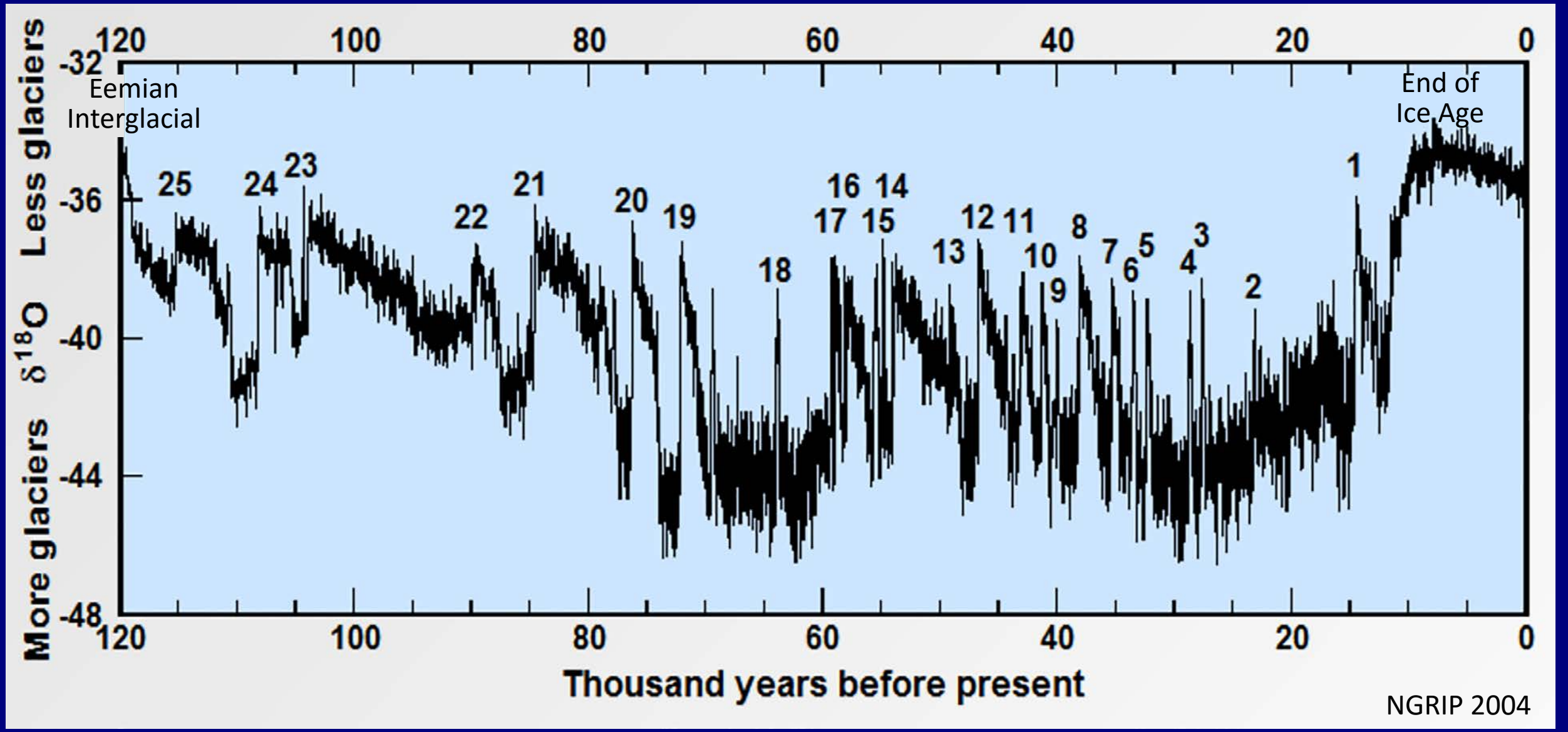
Gregory et al., 2006

Duration of
effusive volcanism

Frequency of
explosive volcanism

Erratic sequences of rapid warming followed by slower cooling

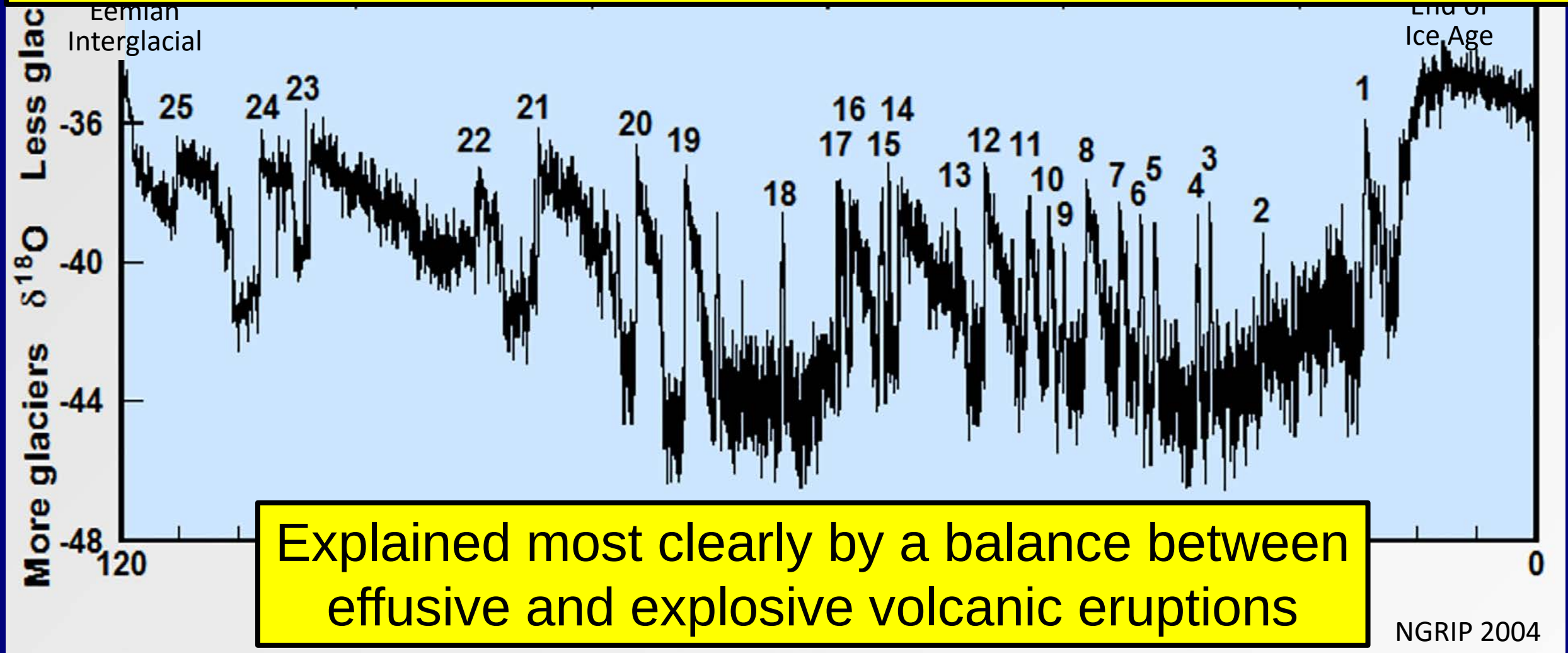
Dansgaard-Oeschger events



NGRIP 2004

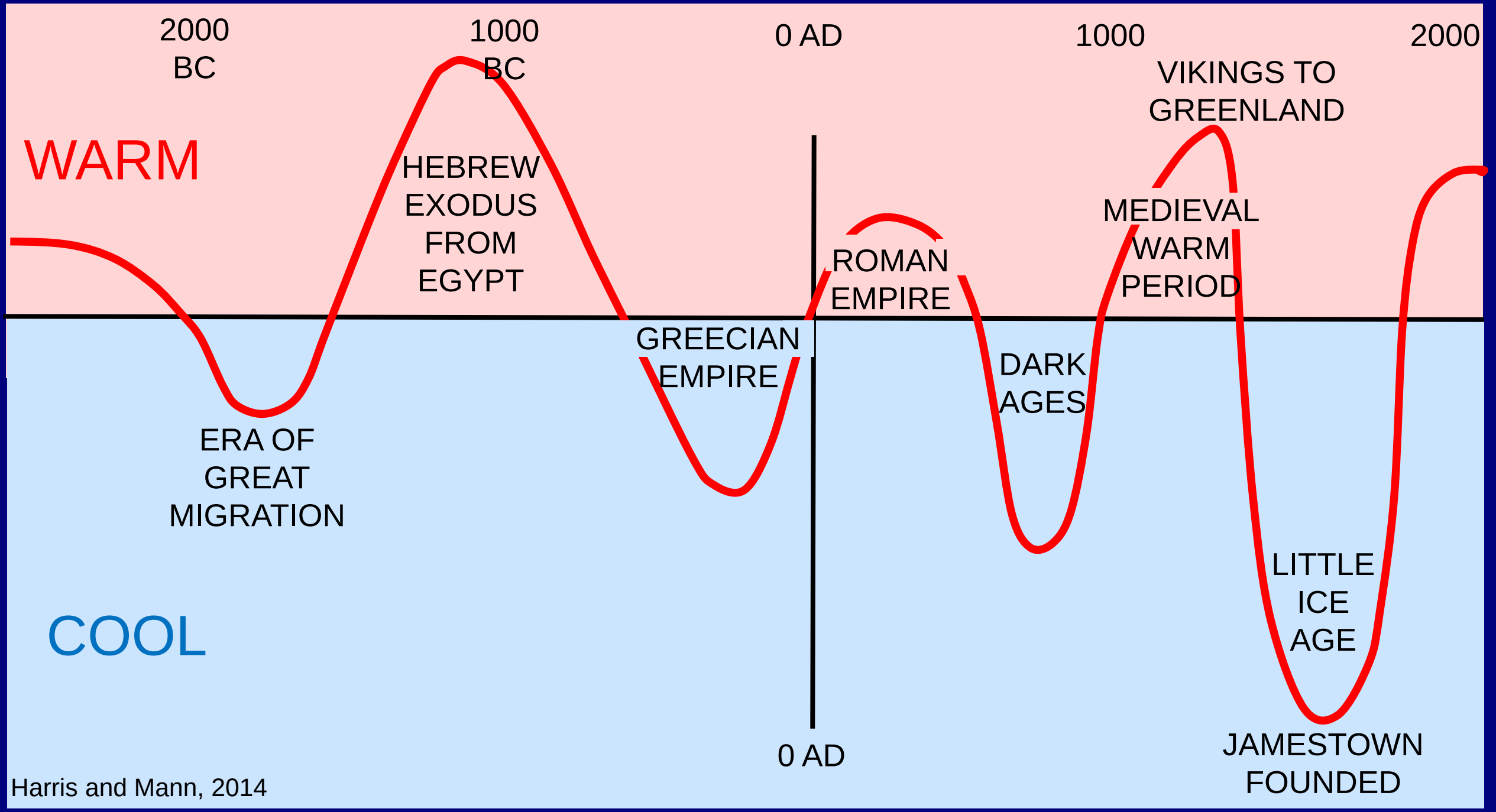
Erratic sudden major warming within a few years followed by cumulative cooling over centuries to millennia

On average, one sequence every 5000 years, but not cyclic



Explained most clearly by a balance between effusive and explosive volcanic eruptions

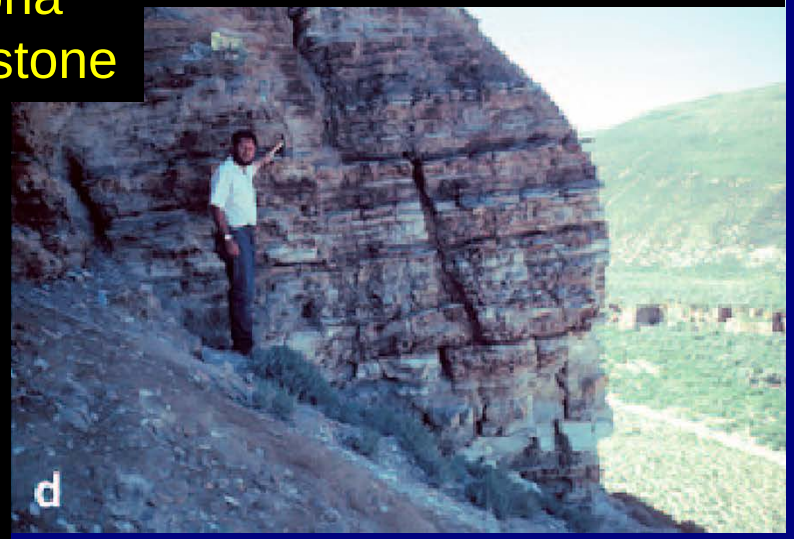
NGRIP 2004


2000 BC
1000 BC
0 AD
1000
2000
WARM
COOL
HEBREW EXODUS FROM EGYPT
ERA OF GREAT MIGRATION
GREECIAN EMPIRE
ROMAN EMPIRE
DARK AGES
VIKINGS TO GREENLAND
MEDIEVAL WARM PERIOD
LITTLE ICE AGE
JAMESTOWN FOUNDED
0 AD
Harris and Mann, 2014

Eocene Green River Formation in Wyoming

53 to 48 million years ago

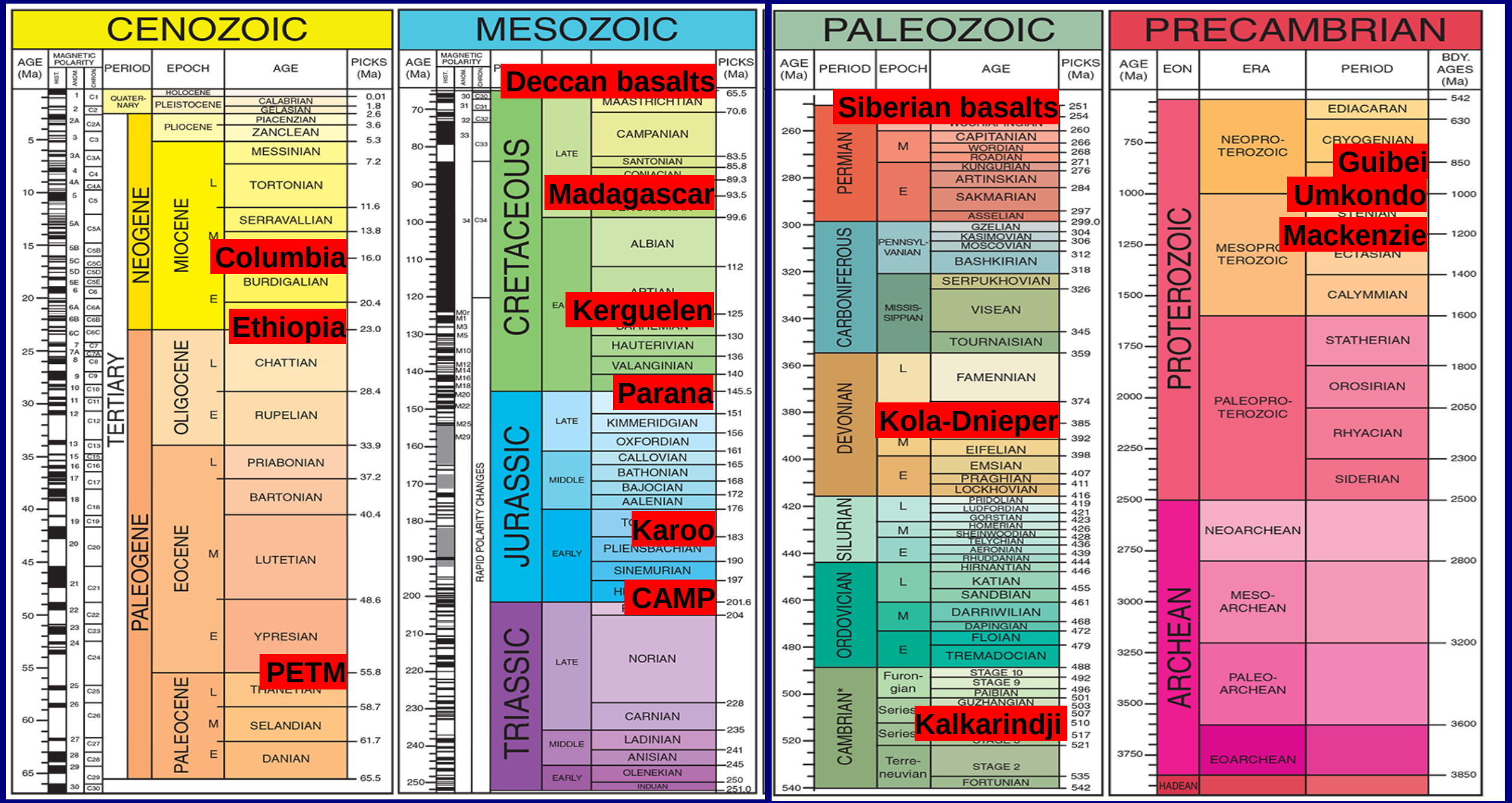
oil shale
trona
dolostone



Mud Lake
Florida
Oil shale

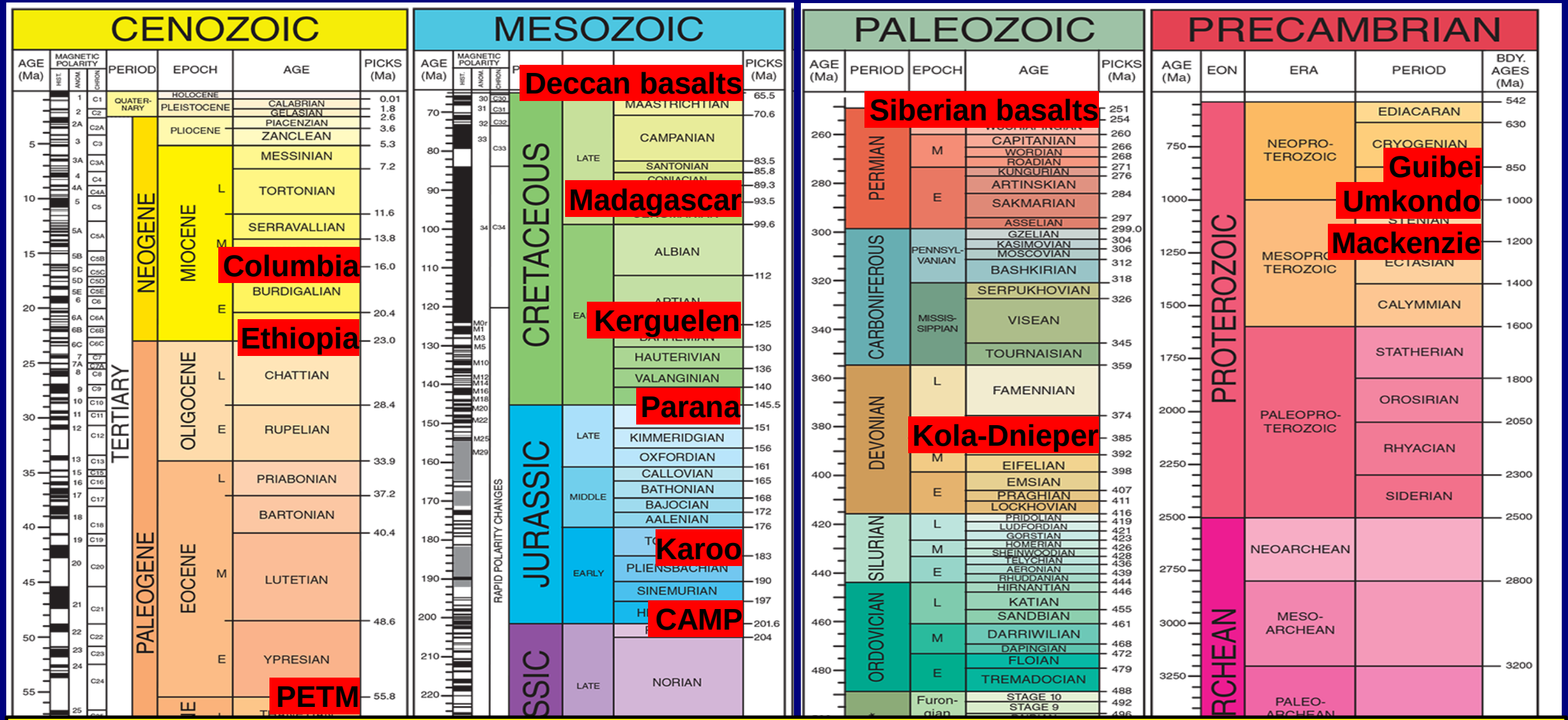
Lake Magadi,
Kenya, Trona

Surdam, 2013



Geological Society of America Time Scale

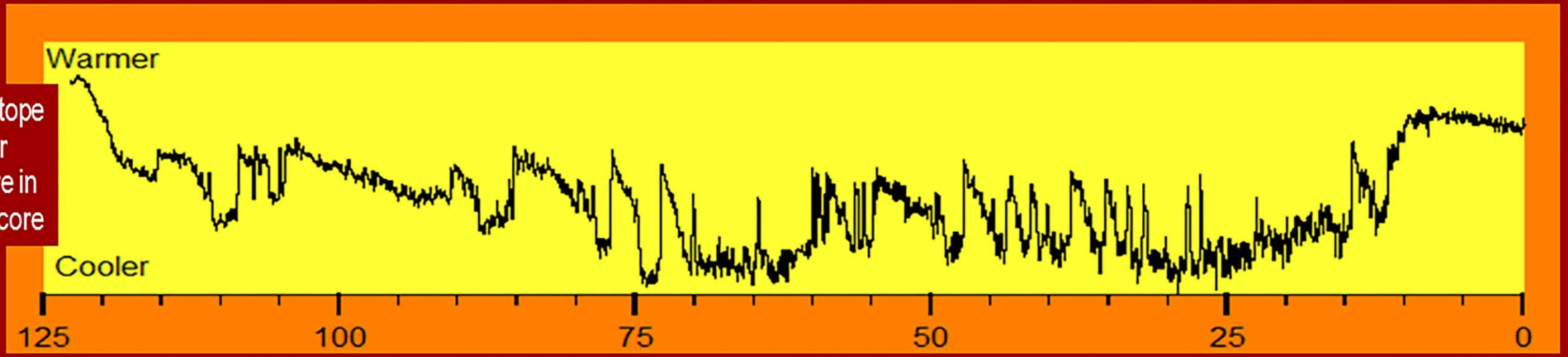
(LIPs from Ernst 2014)



Sudden, massive, rift-related, effusive, basaltic volcanism and associated mass extinctions punctuate the geologic time scale

The Footprints of Climate Change

Sudden warming followed by much slower cooling in erratic sequences averaging 5000 years



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Large effusive basalt flows cause sudden warming

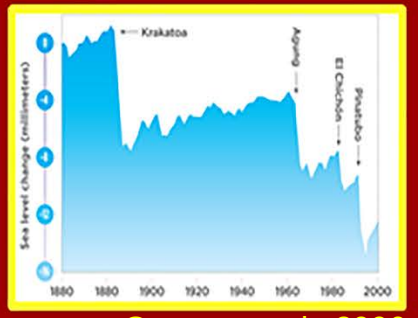
Bárðarbunga 2014

Peter Hartree

USGS

Large explosive volcanic eruptions cause slower cumulative cooling

Pinatubo 1991



Gregory et al., 2006

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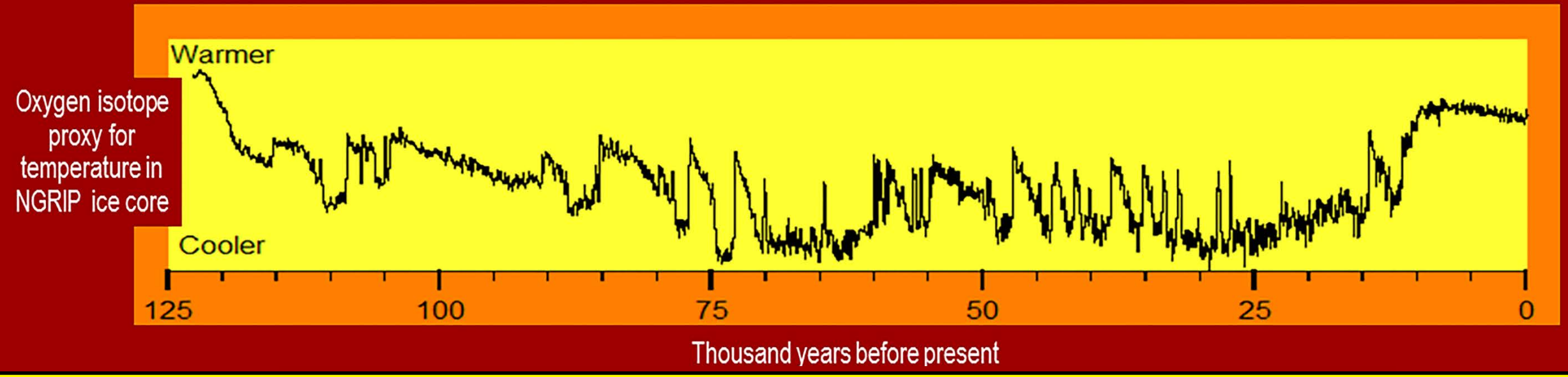

How could greenhouse warming cause such footprints?

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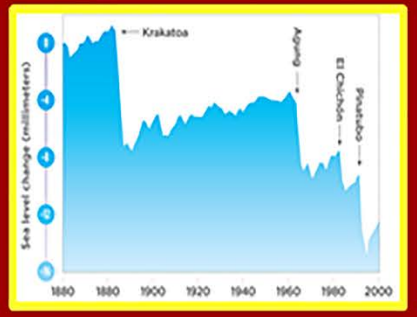

Gregory et al., 2006


Greenhouse
Consensus

The IPCC has spent 28 years crafting greenhouse consensus

Since Paris, 2015, most nations are preparing to spend $10,000,000,000,000 to reduce greenhouse gases

What if this has no effect on global warming?

This could be the greatest economic and political crisis ever created by mistaken science

We Earth scientists need to speak up!

We have to get this right

All citizens of the world are depending on us.

“In science consensus is irrelevant.
What is relevant is reproducible results.”

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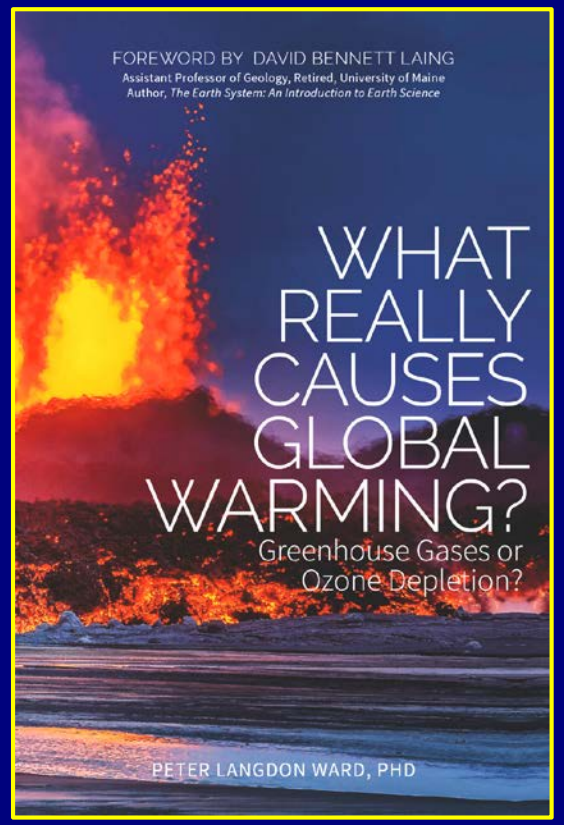
I am actively looking for ways to engage people in discussing the footprints of climate change in the geologic record



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Current Physical Chemistry, 2016, 6, 000-000 1

RESEARCH ARTICLE

Ozone Depletion Explains Global Warming

Peter L. Ward*

US Geological Survey, retired, Teton Tectonics, Jackson, Wyoming, USA

Abstract: When you stand in sunlight, you feel hot, but when you stand outside at night, you feel cool, even on a warm night. Why? Because Sun, with an average surface temperature of around 5770K, emits ultraviolet radiation that is hot enough to burn your skin, while Earth, with an average surface temperature of 288K, emits infrared radiation that is cooler than your body temperature of 310K. Computer models based on greenhouse-warming theory have this backward because they calculate that Earth is heated more by its own infrared radiation than by Sun's ultraviolet radiation. Your personal experience, therefore, strongly suggests that these computer models are not correct. In this paper we show that thermal energy in matter consists of the frequencies and amplitudes of oscillation of all the degrees of freedom of all the bonds that hold matter together. These frequencies and amplitudes of oscillation, on the surface of matter, transmit thermal energy through air and space as electromagnetic radiation (EMR). Climate models assume that thermal energy in EMR is the same at every frequency and add up

Peter L. Ward

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completely than greenhouse-warming theory both in recent times and throughout Earth history. Ozone absorbs extremely “hot” ultraviolet-B radiation from Sun, warming the ozone layer 15 to 30 km above Earth's surface. When there is less ozone, more of this high-energy, very “hot” ultraviolet-B radiation is observed to reach Earth's surface, warming Earth and cooling the ozone layer.

Keywords: Thermodynamics, climate change, ozone, ozone depletion, greenhouse gas, carbon dioxide, explosive volcano, effusive volcano.

WhyClimateChanges.com

In the Exhibit Hall please stop by Booth 564

peward@wyoming.com